PAMBANSANG MUSEO NG PILIPINAS
NATIONAL MUSEUM OF THE PHILIPPINES

FOSSILS

RECORDS OF PREHISTORIC LIFE IN THE PHILIPPINES

FOSSILS

RECORDS OF PREHISTORIC LIFE IN THE PHILIPPINES

Maileen P. Rondal
Jaan Ruy Conrad P. Nogot
Abigael L. Castro
Yloisa C. Magtalas
Jiles Arvin A. Vergara

Edited by
Ana Maria Theresa P. Labrador, PhD.

National Museum of the Philippines

Paperback: ISBN-978-971-567-043-2
Ebook: ISBN-978-971-567-044-9

Published by:

National Museum of the Philippines
P. Burgos Drive, Rizal Park, Manila, Philippines
inquiry@nationalmuseum.gov.ph
gpd@nationalmuseum.gov.ph
Trunkline: (+632) 8298-1100 loc. 1000
Direct line: (+632) 8527-0306

CONTENTS

iii Contents
v Foreword
vii About the Book

1 What are Fossils
2 Becoming a Fossil
4 Understanding Geologic Time
8 *Vicarya* horn snails
10 *Xenophora* sea snails
12 *Strombus* sea snails
14 *Magallanesia canalicuta*
16 *Glyptoactis philippinensis*
18 *Macrosolen madlumensis*
20 Chemosynthetic clams
22 Giant clams
24 *Perisphinctes (Liosphinctes)* Ammonites
26 *Notosilesitoides philippinensis* Ammonite
28 Heteromorph Ammonites
30 Belemnites
32 *Nautilus pompilius*
34 Crinoids
36 Sea Urchins
38 Corals
40 *Megalochelys sondaari*
42 *Otodus megalodon*
44 *Istiompax indica*
46 Freshwater Fish
48 Elephants
50 Stegodons
54 *Nesorhinus philippinensis*
56 *Celebochoerus cagayanensis*
58 *Rusa* sp.
60 Cebu Tamaraw
62 Fossil Plants
66 Petrified wood
68 *Orbitolina*
70 Coprolite
72 Ancient Homes and Tracks

FOREWORD

Fossils are fascinating aspects of our life here on earth. As a young boy, I would often be drawn to fossil exhibitions when visiting natural history museums. This has made me curious about sites I would later visit while touring places – if there are fossils around, how old they might be, and what kind of living beings were around. I have carried this fascination through even as a manager of the National Museum of the Philippines and have been privileged to ensure that fossils found in our country are protected and made accessible by exhibiting and writing about them. This new handbook, Fossils: Record of prehistoric life in the Philippines adds to our growing publications inspired by our exhibitions at the National Museum of Natural History. After reading this, I hope that you will visit our galleries dedicated to fossils, namely, Life Through Time on the fifth floor and the Larry and Pat Gotuaco Fossil Collection
on the ground floor.

Jeremy Barns
Director-General

ABOUT THE BOOK

Have you ever experienced finding any fossils? Perhaps you may unearth some in this book!

Fossils, Records of Prehistoric Life in the Philippines introduces you to some of the amazing fossil discoveries in the Philippines. The plants and animals of our ancient past are represented by specimens from the National Paleontological Collections, arranged taxonomically. When you visit the National Museum of Natural History in Manila, you will see them in a more illustrative form and their stories told in a way that you can compare their present forms. Fossils are three-dimensional proof of our ancient world and helps us imagine what life may have been like before our histories were written.

As a product of the National Museum of the Philippines' #MuseumFromHome series, our Fossil Friday features have been intended as a visual introduction to budding paleontologists that want to learn about our national fossil collections. The series was partly inspired by our friends at the American Museum of Natural History but deviated from it by our focus on our own distinctive fossils. The social media posts became very popular and had a strong following. Some schoolteachers even thanked us for them as they downloaded the posts and became one of their teaching tools.

To disseminate further this knowledge in both digital and printed form, we came out with this book Fossils, Records of Prehistoric Life in the Philippines. We thank Ms. Maileen Rondal and her team for putting this together, as well as her predecessors, Ms. Precy Ong and Mr. Roberto de Ocampo, who, like them looked after the National Paleontological and Geological Collections with diligence and care.

Ana Maria Theresa P. Labrador, Ph.D
Deputy Director-General for Museums

Fossils of broken and disarticulated Jurassic age bivalves and belemnites in sandstone, Oriental Mindoro

What are Fossils?

Fossils are the remains of ancient plants and animals preserved in rocks that are at least 10,000 years old. They were once parts of a living organism, such as shells, bones, teeth, leaves, and flowers from long ago. (called body fossils). Fossils can also be traces of these organisms (called trace fossils) like leaf imprints, footprints, burrows, nests, tracks and trails, or even poops.

The word fossil comes from the Latin word *fossilis*, which means "something dug up," because fossils are often found buried in rock formations deep in the earth.

The study of ancient life based on fossils is called **Paleontology** (pey-lee-uh n-tol-uh-jee), and the scientists that studies fossils are called **paleontologists**. By studying fossils, they learn about what kind of plants and animals were present on Earth, how they lived, and what the environment and climate was like thousands to millions or billions of years ago. Often times, the science involves going to river valleys, cliffs, construction sites, or road cuts to find fossils.

Becoming Fossils

The fossil record is incomplete. While others have simply not yet been unearthed, only a limited number of animals and plants have been preserved. This is because most remains of organisms that die do not resist destruction from environmental and biological factors. Organisms with hard parts like bones, teeth, scales, shells, and wood are more likely to be preserved because they are more resistant to decay and destruction. Consequently, organisms without hard parts like worms and jellyfish have left a meager fossil record.

Where burial is quick and dead organisms are protected from attack by scavengers and bacteria, chemical decay, and weathering, the probability of fossilization improves. Organisms that died in the ocean floor, lakes, deltas, swamps, lowland flood plains, and volcanic areas, where sediment deposition rather than erosion predominates, have a better chance of becoming fossils. This is why a vast majority of fossils are preserved in sedimentary rocks like shale, fine-grained sandstones, and limestones.

Not all fossils, however, are formed by being buried in sediment. In rare instances, an entire organism becomes fossilized because it gets trapped in tree sap (amber), mired in tar pit, or frozen very quickly.

Still, even after a fossil is formed, it can be easily destroyed. Fossils may become flattened beyond recognition when buried by a lot of sediment, or destroyed when exposed to wind, water, and sun. Fossils could also melt when the sedimentary rock itself undergoes extreme pressure and heat and transforms into a metamorphic rock.

Cretaceous age fossilized rudist reef in limestone, Cebu

Understanding Geologic Time

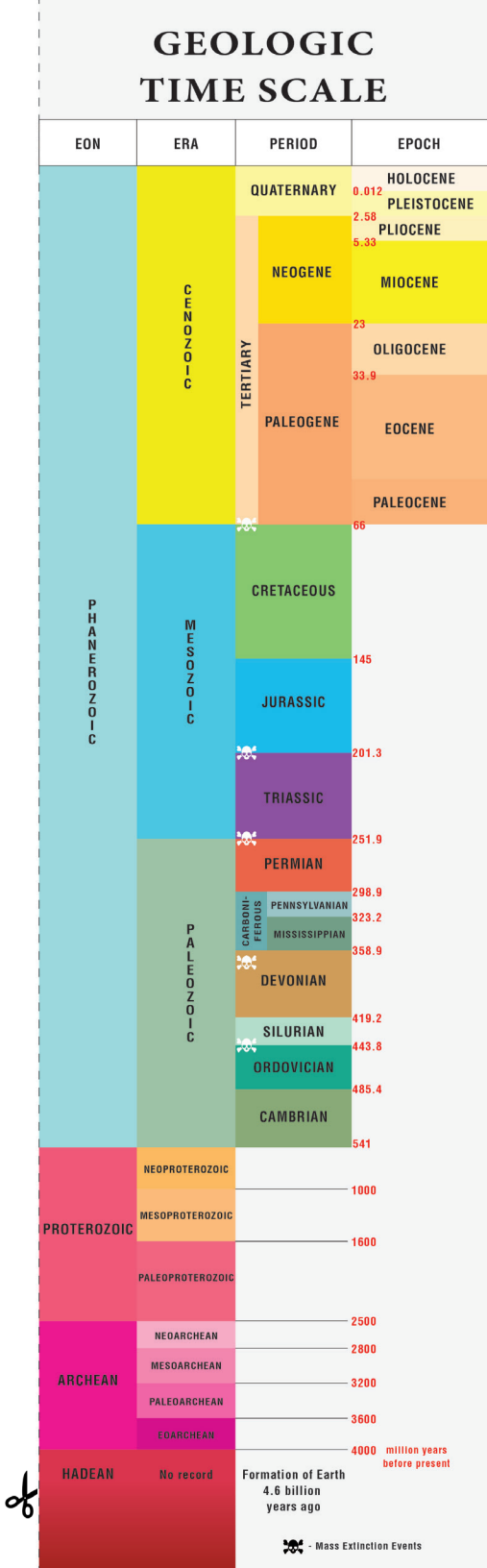
Our Earth is about 4.6 billion years old. That is some unimaginable length of time. To comprehend this long, complex history, scientists created a calendar called the **Geologic Time Scale**. As the name suggests, this is based on different layers of sedimentary rocks that formed during specific times in Earth's history. These rock layers contain a permanent record of the Earth's past, including the fossils of plants and animals buried when the sediments were formed.

The Geologic Time Scale divides Earth's history into a series of four **eons**. Each eon is in turn divided into smaller and smaller units of time. Each divisions mark major events that highlight changes in climate, geography, atmosphere, and life.

Beginning with the oldest, the eons are the **Hadean** ("unseen"), **Archean** ("ancient"), **Proterozoic** ("before complex life"), and **Phanerozoic** ("visible life"). The three oldest eons are part of what is called Precambrian time. It began from Earth's creation and ended with the appearance of complex life forms 541 million years ago. It lasted more than 4 billion years, and represents almost 90 percent of Earth's history.

The Phanerozoic Eon is the current eon and includes the most detailed fossil record. From careful study of the layers of rocks and the abundant fossil record, it is divided into three **eras**. The oldest is the **Paleozoic Era** ("ancient life"), which started with the sudden appearance in the fossil record of complex marine life and ended about 252 million years ago with the End Permian mass extinction, the greatest extinction event in Earth history. Following the Paleozoic Era is the **Mesozoic Era** ("middle life"), which covers the rise of the dinosaurs, and their eventual demise at the End Cretaceous mass extinction. The era also records the first appearance of the first mammals, birds, and flowering plants, as well as the breaking apart of the supercontinent Pangaea. The **Cenozoic Era** ("recent life"), in which we are now living, only began 66 million years ago. During this era, plants and animals look most like those on Earth today.

Don't get lost in time!
Use this bookmark as a learning aid as you go through geologic time. Color markings at the edge of the pages indicate the ages of the featured fossils.



GEOLOGIC TIME SCALE

		FAUNA	FLORA
HOLOCENE	Age of Mammals	*Homo sapiens sapiens*	
PLEISTOCENE		earliest humans	
PLIOCENE		large carnivores	
MIOCENE		Hominids appear	grasslands become widespread
OLIGOCENE		largest mammal (Paraceratherium)	grasslands expands
EOCENE		first horses first cetaceans first primates	abundant forests
PALEOCENE		first large mammals first marsupials	palm trees, cacti
CRETACEOUS	Golden Age of Reptiles	last dinosaurs first primates	first flowering plant
JURASSIC		first bird dinosaurs diversify abundant ammonites	abundant cycads, conifers
TRIASSIC		first mammals first dinosaurs	
PERMIAN		primitive reptiles mammal-like reptiles last trilobites	
CARBONIFEROUS		**Age of Amphibians** giant insects first reptiles	scale trees seed ferns coal-forming swamps
DEVONIAN		**Age of Fishes** first amphibians	
SILURIAN		first jawed fishes first insects	first vascular land plants
ORDOVICIAN		major diversification of animal life	
CAMBRIAN		first fish, trilobites first chordates (animals with backbones)	
PROTEROZOIC		first animal traces first multicellular life primitive jellyfish *Dickinsonia* first acritarchs	
ARCHEAN		**Life begins at sea** cynobacteria (blue-green algae) appears first unicellular life	
HADEAN			

Pleistocene age fossilized coral reef in limestone, La Union

Vicarya horn snails

Gastropod

Vicarya is a prehistoric horn snail that lived in the Philippines about 23 to 5.3 million years ago. It is an extinct genus of horn snails or mudwhelks. Like all sea snails, *Vicarya* had one piece of shell that protected their soft body from predators. In their case, they had a highly conical spiraled shell with many triangular protrusions growing around it. They lived on the surface of brackish-water environments, on mudflats of estuaries and in mangrove swamps, where they graze on growing grass, herbs, and other algae. Although they had limited visibility, they are believed to be actively mobile.

The genus has been around since the Early Cretaceous (about 112 to 109 million years ago) until their extinction about 11.6 to 5.3 million years ago. It has attracted much attention among paleontologist because they represent stratigraphically important index fossils, which means they are important in determining the age of rocks. *Vicarya* fossils are representatives of several Miocene (23 to 11.6 million years ago) localities throughout the Philippines.

The National Paleontological Collections contain about a hundred *Vicarya* fossils. Some even have their color markings preserved. The featured specimens were collected from the municipalities of Calatrava and Candoni, and in City of Sipalay in the province of Negros Occidental. Similar fossils were also discovered in Argao and San Fernando, Cebu, and in Ilagan, Isabela.

5 cm

Xenophora sea snails

Gastropod

The name *Xenophora* comes from ancient Greek words that means "bearing (or carrying) foreigners" because this snail collects shells, small rocks, dead corals, even bottle caps and coins, and glues them to its shell as it grows. Using these foreign objects, it creates a radiating, spiral pattern on its shell surface. Every so often, the effect is more of a jumble of debris like a miniature undersea mosaic.

Xenophora snails adorn their shell to make it bigger and stronger. The adornments also provide visual camouflage. Predators lurking from above may mistake them as just a pile of debris. The objects are also believed to act as support allowing them to lift their soft body parts up off the seabed giving them olfactory camouflage. This peculiar activity makes *Xenophora* snails as the supreme camouflage artist in the world of shelled-organisms.

Xenophora snails have been around during the time of the infamous T-Rex, and have survived to this day. In the Philippines, you can find them in Manila Bay, Sulu Sea, and the shallow waters off Bohol and Cebu. In 1977, a specimen of Pliocene age (5.33 to 2.58 million years old) was discovered preserved in calcareous sandstone in Brgy. Tiep, Bani in Pangasinan. In 2020, the National Museum, together with geologists from UP-NIGS and NMNS-Japan collected several *Xenophora* shells (featured here) from the riverbed of Magat River in Ramon, Isabela. It is believed that the creatures inhabited the area when it was covered by a shallow sea some 8.2 to 5.5 million years ago.

Take a closer look at the featured fossils. Can you pick out the foraminifera tests and shells of small clams and other sea snails embedded on the surface of the shells? As its shell grows larger, it can handle larger materials. Interestingly, the snail likes to arrange the bivalve (clam) shells upside down, and gastropod (snail) shells with the opening facing up. Aren't they quite meticulous!


3 cm

Strombus sea snails

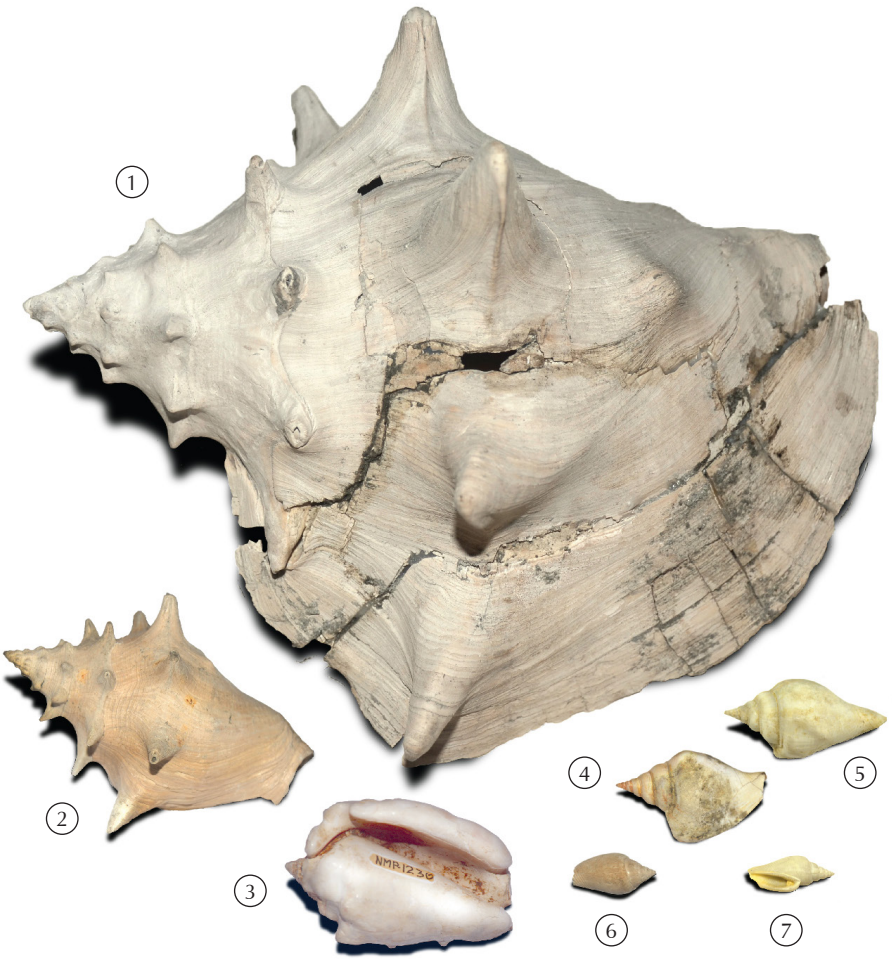
Gastropod

Strombus is a genus of medium to large sea snails in the family of true conches, the Strombidae. Swedish Naturalist Carl Linnaeus named it in 1758. These sea snails come in many shapes and sizes. Commonly they are called dog conch snails (*Strombus canarium*), humpbacked conch snails (*Strombus gibberulus*), silver conch snails (*Strombus lentiginosus*), strawberry conch snails (*Strombus luhuanus*), and fighting conch snails (*Strombus pugilis*). *Strombus* shells, however, are distinguished from those of other sea snails by having a wing-like outer lip with a notch in the edge of the shell aperture. This notch is called a stromboid notch and allows the animal to extend one of its two stalked eyes out.

Strombus snails has about 50 recognized living species of various sizes. Its fossils have been found all over the world in sediments going back to the age of the dinosaurs - 145 million years ago in the Cretaceous Period. The Geology and Paleontology Division manages a wide array of *Strombus* fossil specimens since 1976 with localities all over the Philippines, specifically from the provinces of Agusan del Norte, Batangas, Bohol, Bulacan, Cebu, Iloilo, La Union, Negros Occidental, Quezon, Pangasinan, Zambales. Most are them are about 16 million years to 1 million years old. The largest among them is the *Strombus maximus* from Compostella, Cebu.

Strombus are tropical to subtropical and often unreserved animals, mainly living in shallow water, on sandy, muddy or rubble bottoms or on marine grassflats. They are very active and often use their narrow foot and strong operculum in a leaping locomotion and as a defensive weapon. They are mostly herbivores, browsing on delicate algae, or swallowing sand and rubbish to digest the decomposing plant matter. Males are also frequently smaller than females. Fertilization occurs internally with numerous eggs, laid in gelatinous, tubular, tangled masses, and hatching as planktonic larvae.

Today, large species of *Strombus* are commercially fished for food in many parts of South East Asia. In the Philippines, shells are traditionally used by fishermen as sinkers for nets while some used them as shellcraft.



1 *Strombus maximus* (adult)
2 *Strombus maximus* (juvenile)
3 *Strombus lentiginosus*
4 *Strombus canarium*
5 *Strombus gibberulus*
6 *Strombus unifasciatus*
6 *Strombus pugilis*

Magallanesia canaliculata

Rudist

Reefs were not always made of corals. About 100 million years ago, they were built by an unusual group of clams called rudists. Unlike today's familiar clams, these clams of the dinosaur age developed strange-looking shells. One shell was typically larger and attached to the seafloor and the other, smaller shell acts like a lid similar to trashcans. Other shell forms resemble ice cream cones, goat's horns, and croissant breads. Because of their shell, they became hardly recognizable as clams at all. Nevertheless, they are quite the record keeper. From their shells, scientists were not only able to determine that the ocean temperatures were warmer back then (reaching 40°C), but also discovered from their growth rings that about 70 million years ago, the Earth's day is 30 minutes shorter and a year had 372 days. Rudists dominated the tropical shallow seas throughout the heyday of the dinosaurs until its extinction about 66 million years ago. Today, their fossils are found in limestone formations throughout the Mediterranean, the Middle East, the Caribbean, and the Southeast Asia where sometimes they constitute major oil reservoirs

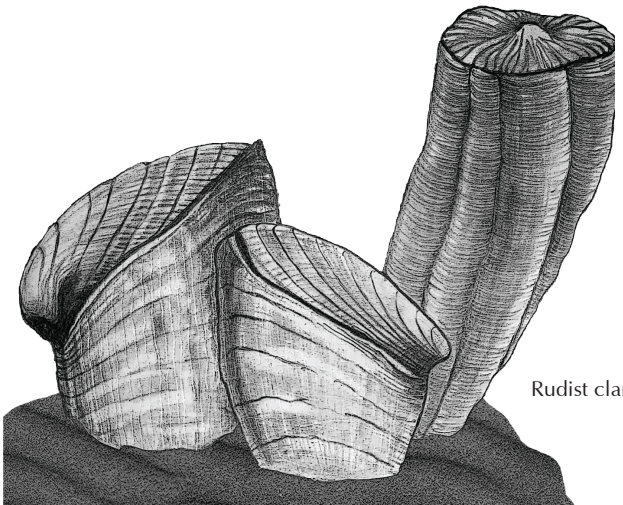
In the Philippines, the first reported rudist fossil was discovered in Cebu in 1988. Fossilized rudist reef was also unearthed in Caramoan in Camarines Sur. In 2013, through a collaborative research between the Mines and Geosciences Bureau (MGB) and the National Museum of Nature and Science (Tokyo, Japan), remains of a never-before-seen rudist were uncovered, preserved in limestones, along the Butuanon River in Barangay Pulangbato, Cebu City. They named this new species *Magallanesia canaliculata* after Ferdinand Magellan, and the notable canals in the inside of the smaller shell (Sano et al., 2014). According to the paleontologists, like Magellan's expedition, the lineage for the Cebu rudist is supposed to have originated in the western Mediterranean, and then entered and evolved in the equatorial Pacific. Another fossil of *M. canaliculata* was also discovered in Takuyo-Daini Seamount in the Japanese Seamounts, northwest Pacific. The discovery of these fossils strengthens the evidence that they were probably endemic to the Pacific, 100 to 113 million years ago.

Sano, S., Iba, Y., Skelton, P. W., Masse, J-P., Aguilar, Y. M., & Kase, T. (2014). The evolution of canaliculate rudists in the light of a new canaliculate polyconitid rudist from the Albian of the Central Pacific. *Paleontology*, *57*, 951-962.

HOLOTYPE, NMP-1376

5 cm

PARATYPE, NMP-1375



Rudist clams

Glyptoactis philippinensis

Bivalve

Glyptoactis philippinensis is a marine clam that lived in the Philippine waters about 11.63 – 5.33 million years ago (late Miocene). This clam would have been found on the bottom of warm, shallow, near-shore waters, feeding by filtering out plankton or nutrients suspended in the water. It is now extinct.

Interestingly, this belongs to a family of clams commonly known as Little Heart Clams (Carditidae), named after the form of its small shell. The shell is equivalve (right and left half-shell called valves are mirror images), inequilateral (halves of the valve lack symmetry), and nearly triangular with prominent and well-rounded umbone.

One fascinating characteristic of this clam is that the surface of the shell is sculptured with 17-18 radial ribs, which disappear on its posterior side when it becomes an adult. Did you know that this clam also had teeth? These are called cardinal and lateral teeth. They use them to align the valves as they close it, protecting them from a predator by making it harder to open their shell.

Glyptoactis philippinensis fossils can be found excellently preserved in a sequence of greenish gray, poorly consolidated sandstone and mudstone belonging to Tartaro Formation in Madlum, San Miguel, Bulacan. The first fossils of this clam were found near the Tartaro Bridge in San Miguel, Bulacan in 1981 by Japanese paleontologist Saburo Kanno and his colleagues, who will later name them after the Philippines (Kanno et al., 1982). In the meantime, the Geology and Paleontology Division were able to collect the featured fossils (NMP-0933) in Madlum, San Miguel, Bulacan in 2002.

Kanno, S., O'hara, S., & Caagusan, N. L. (1982). Molluscan fauna from the Tartaro Formation (Upper Miocene) of Central Luzon, Philippines. *Geology and palaeontology of Southeast Asia*, *24*(232), 51 -128.

1 radial ribs
2 umbo
3 lateral teeth
4 cardinal teeth
5 posterior abductor muscle scar (pear-shaped)
6 anterior abductor muscle scar (elliptical)

Macrosolen madlumensis

Bivalve

Macrosolen madlumensis is a prehistoric clam that inhabited the earth from the Eocene to Miocene Epoch (37.71 – 7.246 million years ago). It had a thin, oval, transversely elongated shell with narrowly rounded frontal section. The posterior part of the shell is much broader than the anterior part. The entire shell surface is marked with growth lines while the posterior half of the radial furrow has concentric wrinkle-like folds. Their shells were also quite thin and fragile. This is the reason why most specimens recovered are usually fragmented especially those deposited in loose sediments. They are believed to be slightly deep burrowers, preferring to live completely buried within the seafloor. This extinct clam was named after the locality it was discovered, the Madlum River of San Miguel, Bulacan.

Fossils of *M. madlumensis* can be found preserved in the 11.63 – 5.33 million year old (late Miocene – early Pliocene; Villanueva et al, 1995) Tartaro Formation. This formation is a sequence of greenish gray, poorly consolidated sandstone and mudstone. In addition to *M. madlumensis*, the formation also contains an abundant number of fossil gastropods (snails), pelecypods (clams), scaphopods (tusk shells), and a few coral fragments, reflecting a shallow, near shore or lagoonal environment. Kanno and colleagues (1982) describe in detail the molluscan fossils of the Tartaro Formation, which includes the discovery of 5 other new species of clams and 2 gastropods. Most of the fossil clams recovered from this area occur as detached shells although there are quite a few that are intact and articulated. This suggest that the fossils were transported by some current from their original home, which is relatively near the present fossil locality.

Featured here are specimens of *M. madlumensis* (NMP-942, NMP-1346) collected by the Geology and Paleontology Division in 2002 and 2013. They were found near the Madlum River in Sitio Pulang Lupa, Brgy. Sibul, San Miguel, Bulacan. The surrounding siltstone matrix keeps the thin fragile shell in shape.

Kanno, S., O'hara, S., & Caagusan, N. L. (1982). Molluscan fauna from the Tartaro Formation (Upper Miocene) of Central Luzon, Philippines. *Geology and palaeontology of Southeast Asia*, *24*(232), 51 -128.


NMP-1346


NMP-1346


NMP-0942

5 cm


M. madlumensis clam
burrying within the seafloor

Chemosynthetic Clams

Bivalve

Wareniconcha and *Calyptogena* belong to the family of vesicomyid bivalves (clams) that appeared approximately 42 million years ago (Middle Eocene). They live in deep-sea volcanic vents or cold seeps, which are cracks on the ocean floor typically found at tectonic plate boundaries and where hydrogen sulfide, methane, and other hydrocarbon-rich fluid are released. Instead of a photosynthesis-based nutrition, these clams rely on bacteria in their gills to convert the carbon compound released from the vent into food (e.g. sugar) via a process called chemosynthesis.

In the Philippines, fossils of *Wareniconcha* and *Calyptogena* are found in a Pliocene (about 5 million years old) methane-seep carbonate deposit in the island of Leyte. They were first discovered at Liog-liog Point, Tabango by a group of Japanese and Filipino paleontologists led by Dr. Tomoki Kase of the National Museum of Nature and Science in Tokyo. The clam *Wareniconcha mercenarioides* (no. 4 below), is a new species they found and the first fossil record of *Wareniconcha*. Compared to the living species, it is larger (length 11.3 cm, height 10.1 cm, width 5.7 cm), has more inflated and more rounded shell outline (Kase et al., 2019).

The *W. mercenariodes* paratype, donated by Dr. Kase in 2018, is currently being safeguarded by the National Museum of the Philippines. On the other hand, fossils of the more elongate-elliptical shelled *Calyptogena* were found as in-situ, densely packed colonies, and were associated with other bivalve species *Lucinoma* and *Thyasira*. These fossil cold-seep assemblages in Leyte were the first record in Southeast Asia.

In 2015, the National Museum of the Philippines visited the site and the nearby municipality of San Isidro, and have collected several *Calyptogena* fossils, which are currently on display at the "Life Through Time" exhibition at your National Museum of Natural History. Discovering more fossils of chemosynthetic organisms like these clams are important in understanding deep marine ecosystems, and identifying ancient volcanic-vents or cold seeps that can be used in reconstructing the past movement of tectonic plates.

Kase, T., Isaji, S., Aguilar, Y. M., & Kiel, S. (2019). A large new Wareniconcha (Bivalvia: Vesicomyidae) from a Pliocene methane seep deposit in Leyte, Philippines. *The Nautilus*, *133*(1), 26-30.

1,2 *Calyptogenia* sp.
3 *Calyptogenia* colonies
4 *Wareniconcha mercenarioides* (PARATYPE)

Giant Clams

Bivalve

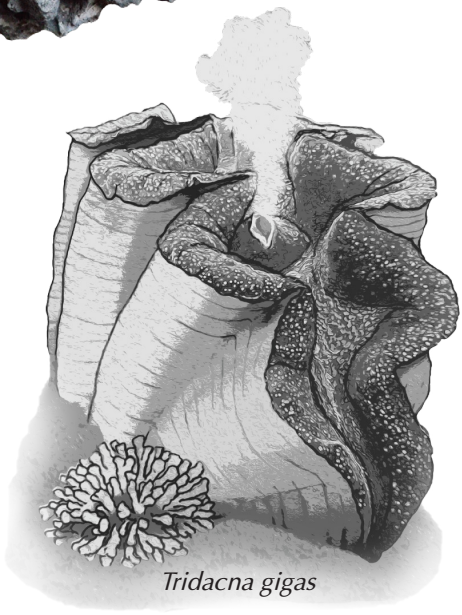
Locally known as kabibe, kima, taklobo, manglut, or saliot, giant clams (Tridacnidae) are a family of large saltwater clams that live in warm, shallow waters on coral reefs. They first appeared about 23 million years ago in the Early Miocene. Living species are commonly found in the tropical coral reef of the Indo-West Pacific seas. Although fossil evidence in Northern Europe, Florida, and Austral Islands shows that they once had a greater distribution in the past.

Giant clams are indeed giants as the largest species, *Tridacna gigas*, can grow to 1.3 meters wide and weigh up to 250 kilograms. They achieve their impressive size by filter feeding and consuming the sugars and proteins produced by billions of symbiotic algae (called zooxanthellae) living in their mantle. As they grow, they loss their ability to move and just fasten themselves to a spot on the reef, where they sit for the rest of their life.

Here in the Philippines, 7 of the 9 living species thrive, and numerous fossils have been reported throughout the archipelago. The fossil *T. gigas* featured here was discovered in 2014 by the National Museum in a limestone formation in Pamilacan Island, Bohol. *T. gigas*' shell is thick, heavy, with 4 to 5 large, inward, vertical folds, and lacks scutes (shelf-like structure). This clam lived about 3.6 to 1.8 million years ago, when the island was then part of the sea. You can still see the fossilized coral reef around it that served as the animal's home. Through the shape, chemistry, and daily growth increments in their shell, similar to tree rings, fossil giant clams like this one allowed researchers to accurately investigate past environmental changes.

Today, both living and fossil giant clams are threatened by widespread overexploitation. The increased interest in clam pearls in recent years have only intensified this. In the Philippines, taking, selling and consumption of giant clams are prohibited under the Philippine Fisheries Code 1998 (RA 8550). Fossils are also considered as Important Cultural Properties, pursuant to "Cultural Properties Preservation and Protection Act" (RA 4846 as amended by PD 374), and likewise, protected by law.

SIZE RELATIVE TO 5-FT WOMAN



Tridacna gigas

Perisphinctes (*Liosphinctes*) Ammonites

Cephalopod

Ammonites (am-uh-nahyts) were squid-like sea creatures that existed before and all the way through the age of dinosaurs. They were carnivores that lived inside ribbed coiled shells. While they may look like chambered nautiluses, their closest living relatives are squids, octopuses, and cuttlefishes.

Many different forms of ammonites occurred only at certain time periods. *Perisphinctes* (*Liosphinctes*) only appeared around 160 million years ago in the Late Jurassic (Middle Oxfordian). Its shell is shaped like a coiled snake with fine dense ribs that gradually changes to more distant, coarse ribs. This ammonite form was widespread in warm to temperate shallow saltwater environments worldwide.

In February 2011, a team from the National Museum of the Philippines, Mines and Geosciences Bureau, and the National Museum of Nature and Science (Japan) discovered two fossils of this form in the municipality of Mansalay in Oriental Mindoro. The original shells were already lost. What remained are impressions of their interior called an internal mold. These were formed from hardened mud that filled up the inside of the shell, and were left behind when the shell was dissolved. The specimens belonged to the Mansalay Formation. Since the creature only lived during the Late Jurassic, these fossils acted as markers in time (index fossil), helping geologists identify the age of the rock formation. These specimens are two of the oldest megafossils found in the Philippines, and among the few remnants of Jurassic fauna in the country.

Sato, T., Kase, T., Shigeta, Y., De Ocampo, R., Ong, P. A., Aguilar Y. M., & Mago, W. (2012). Newly collected Jurassic ammonites from the Mansalay Formation, Mindoro Island, Philippines. *Bulletin of the National Museum of Nature and Science, Series C, 38*, 63-73.

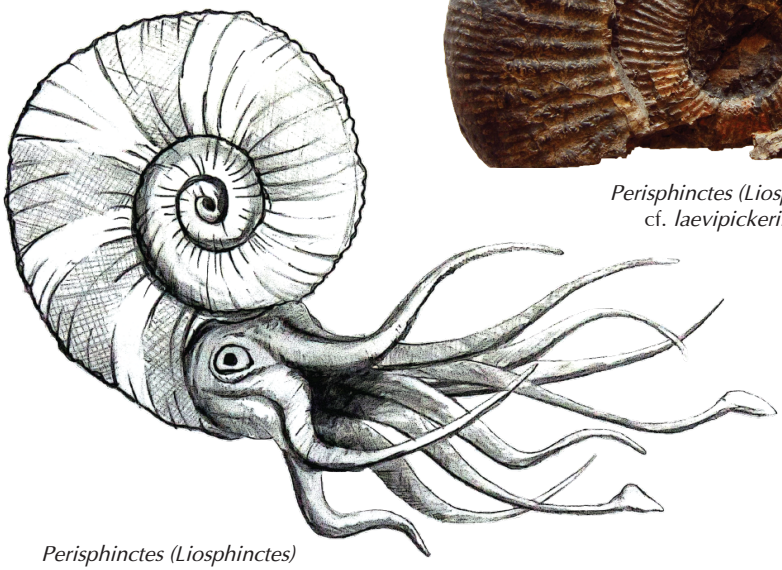
NMP-1403

Perisphinctes (Liosphinctes) sp.

5 cm

NMP-1089

Perisphinctes (Liosphinctes)
cf. *laevipickeringius*



Perisphinctes (Liosphinctes)

Notosilesitoides philippinensis Ammonites

Cephalopod

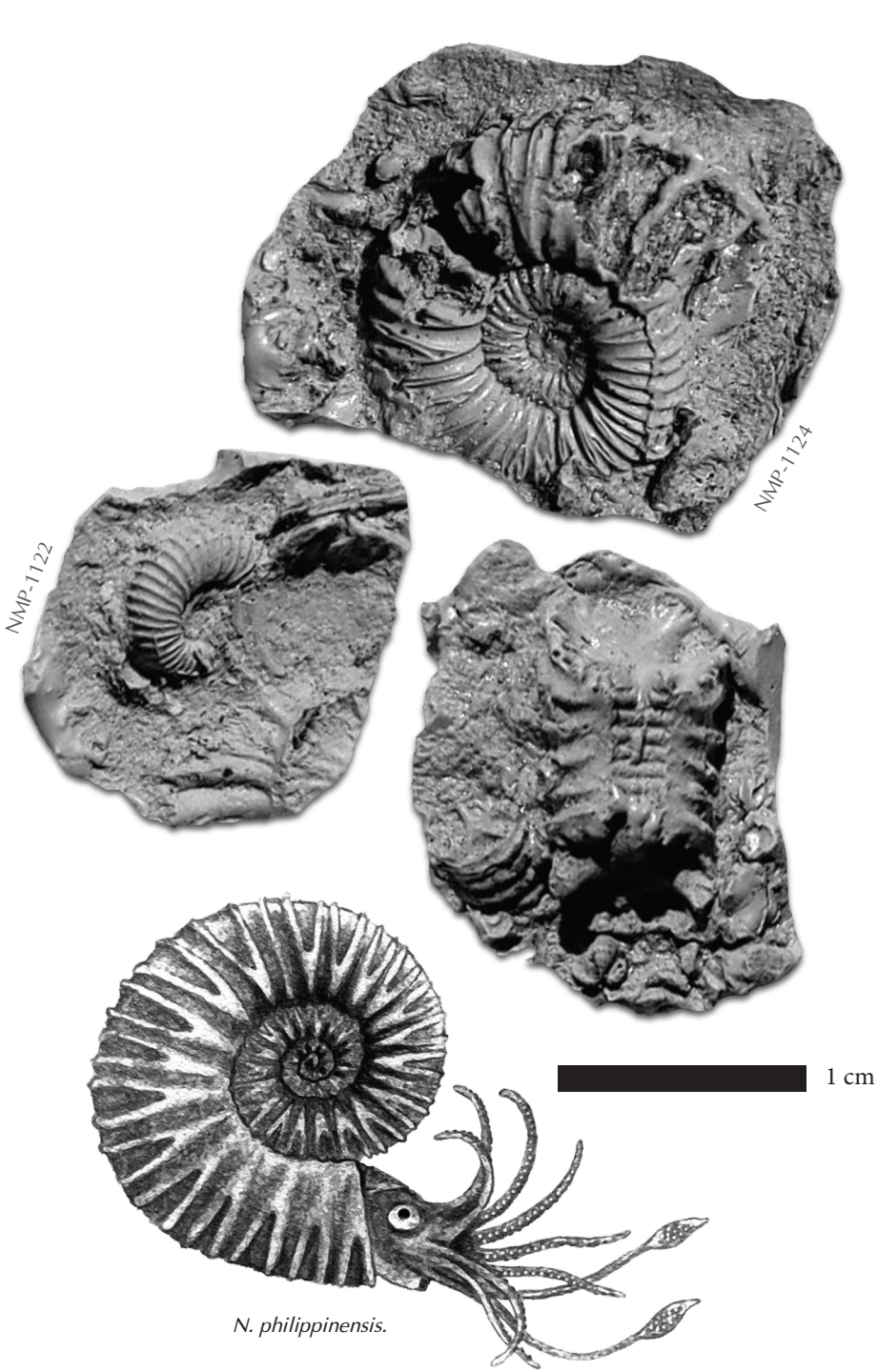
Along the Comagaycay River in San Andres, Catanduanes, a group of ammonite fossils was discovered in 1982. The remains of these squid-like creatures were collected by a group of paleontologists and geologists from the Mines and Geosciences Bureau and the Tokyo University.

A total of nine (9) ammonite species were identified, preserved in fine-grained sandstone presumably belonging to the Yop Formation. The age of the ammonite-bearing sandstone is estimated to be Aptian-early Albian (about 125-113 million years old). Among the ammonites discovered is a new species they called *Notosilesitoides philippinensis* (Matsukawa et al., 2012).

This particular ammonite was first discovered here in the country and the researchers chose to name it after the Philippines. This ammonite has a really small shell, is polygyral (many whorls) and has an evolute whorl, resembling a coiled snake, with ribs that bifurcate or branches into two. Three specimens of this species were recovered. One of these individuals is assigned as the holotype (NMP-1124). All the ammonite fossils from this site were turned over by the original researchers to the Geology and Paleontology Division right after the publication of the study.

A holotype is the single specimen selected by the taxonomist as reference point in describing a new species. Therefore, it is the most important specimen of any species. By virtue of RA 10066 otherwise known as the National Cultural Heritage Act of 2009, the National Museum of the Philippines is the official repository of holotype specimens of fossils and extant flora and fauna collected in the Philippines.

Matsukawa, M., Sendon, S. V., Mateer, F. T., Sato, T., & Obata, I. (2012). Early Cretaceous ammonite fauna of Catanduanes Island, Philippines. *Cretaceous Research*, *37*, 261-271.



N. philippinensis.

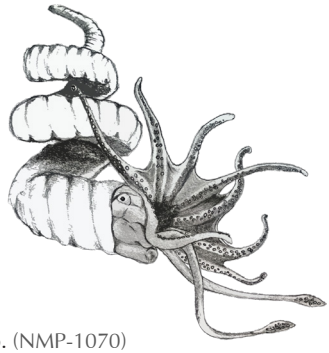
Heteromorph Ammonites

Cephalopod

Heteromorph (different shaped) ammonites are an extinct group of externally shelled cephalopods with unusual shell shape. They were particularly abundant and diverse during the Cretaceous period (145-66 million years ago). Compared to most ammonites, they do not have tightly coiled shell. They show a remarkable change of shell shape as they approach adult (mature) stage. Juvenile or immature ammonites could develop any type of shell coiling, including the planispiral shell typical of "regular" ammonites. As they reach maturity, they uncoil the last whorl of their shells to form a U-shaped body chamber. A variety of irregular shape could develop among heteromorphs. Some resemble a paper clip, an elephant's trunk, while other shells could uncoil into a completely straight line.

It is interesting to imagine how these shapes would have given heteromorphs an evolutionary advantage since they made them poor swimmers. This leads paleontologists to think that many either drifted in the open ocean like today's jellyfishes, or crawled along the sea floor, like their living relative, the octopuses. The shell shape may have also contributed to the fragility of the shell. As such, complete heteromorph ammonites in the fossil record are rarer compared to the tightly coiled ammonites.

In 2009 and 2010, several ammonite fossils, including the heteromorph ammonites were collected in Catanduanes by a team from the National Museum of the Philippines, the Mines and Geoscience Bureau, and the National Museum of Nature and Science (Japan). These fossils were first reported by Mr. Oseas Alberto, a local who accidentally found the fossils while on a trek at the Silungan ng Higante in San Andres, Catanduanes. These fossils were preserved in sandstone of the Yop Formation, formed about 100 million years ago (Upper Albian). Examples of heteromorph ammonites collected include the *Pseudhelicoceras* sp. (NMP-1070), *Hamitoides* sp. (NMP-1069b), and *Hamites* sp. (NMP-1011). As with the Jurassic ammonites of Mindoro, only the mold of the original shell is preserved for most of the ammonites found here.



Pseudhelicoceras sp. (NMP-1070)

Hamites sp.
(NMP-1011)

Hamitoides sp. (NMP-1069b)

5 cm

Belemnites

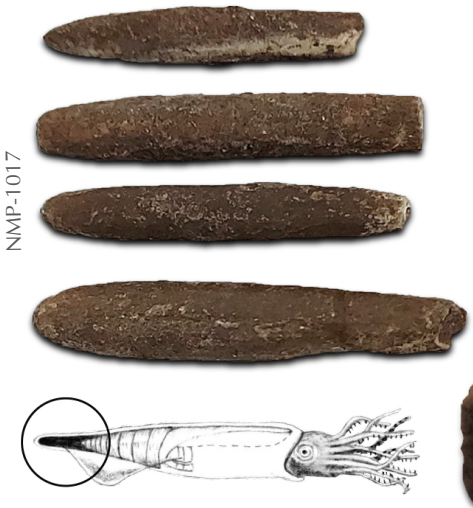
Cephalopod

Belemnites (bel-uhm-nahyts) are members of an extinct group of cephalopods (animals related to today's squid, cuttlefish, and octopus) that lived from the early Late Triassic (about 237 million years ago) through to the end of the Cretaceous (66 million years ago). Unlike their living relatives, belemnites possessed a hard internal skeleton at their tail end called a rostrum (plural: rostra; encircled here). This bullet-shaped feature acted as counterbalance for the head and arms during swimming. The name 'Belemnite' is actually derived from the Greek word "belemnon" that means javelin or dart due to the resemblance in the shape of the rostrum. Because the soft body of the animal is rarely preserved, it's usually just the rostrum that's fossilized.

In addition to the rostrum, belemnites had ten arms and did not possess a pair of tentacles Each arm was equipped with 30-50 curved hooks for grabbing crustaceans, other cephalopods, and fishes. If threatened, they could squirt a cloud of ink into the water to aid their escape. But, belemnites themselves were prey for larger marine creatures, like sharks, ichthyosaurs, and other marine reptiles, as they have been found with rostra in their stomachs.

The National Geological and Paleontological Collection contains a number of belemnite rostra collected from the provinces of Catanduanes and Oriental Mindoro. Specimens of the belemnite species, *Neohibolites* sp. (NMP-1017 and NMP-1042) were collected on April 8, 2009 and March 15, 2010 at Silungan ng Higante, San Andres, Catanduanes. These specimens are estimated to be 100 million years old. On the other hand, specimens of the belemnite, *Hibolithes* sp. (NMP-1079) were collected on February 17, 2011 at So. Colasi, Cabalwa, Mansalay, Oriental Mindoro, and are Jurassic in age (over 150 million years old).

For several years now, geologists and paleontologists have used fossil belemnites, not only to determine the age of rocks, but also to understand the environmental conditions (e.g. temperature, productivity) in the past.



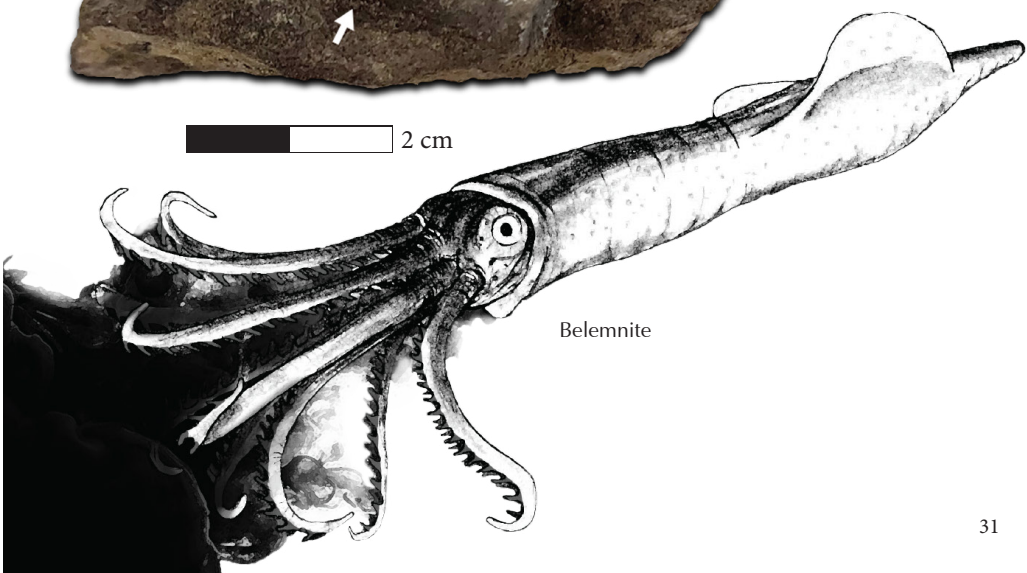
NMP-1017

Neohibolites sp.

NMP-1042

Hibolites sp.

2 cm



Belemnite

Nautilus pompilius

Cephalopod

Nautilus pompilius or emperor nautilus (nawt-l-uhs, also called pearly nautilus) are distant relatives of octopuses and squids. They possess an external coiled hard shell which has many interior compartments or chambers. These chambers provide buoyancy and aid in the mobility of the organism. The shells could grow up to 22 cm in diameter. The shell color patterns may vary but they commonly appear as brown to reddish brown flame-like stripes. They are deep-water organisms. They mostly swim in the continental shelf or slope part of the ocean at depths of up to 750m. They are found in the Indo-West Pacific region including the Philippines, Papua New Guinea, and Northwest Australia. They are scavengers and their diet consist mainly of crustaceans and fishes. Currently, nautiluses are not classified as endangered nor threatened species by the IUCN however, there have been increasing calls to ban the commercial trade of nautilus shells. The large and beautifully colored shells of nautiluses are popularly sold as souvenir items or jewelry and home accessories.

Nautiluses are often called living fossils because their appearance remains unchanged for the last 500 million years. They are the only surviving species of the shelled cephalopods which were present in the earth's oceans during the Paleozoic (~541 million years) and Mesozoic (~252 million years). They even survived through the 5 major global extinction events. In contrast, the ammonites which closely resemble the nautiluses, went extinct about 66 million years ago.

In the Philippines, the fossil of a *Nautilus pompilius* was first discovered in Tambac Bay, Bolinao, Pangasinan. The same area where the fossil black marlin was also discovered 25 years prior to the nautilus. The fossil is a moderately preserved shell consisting of the last two chambers of the phragmocone and the entire body chamber portion. The fossil (NMP-491b) was collected by the Geology and Paleontology Division in 1979 from a bioturbated, unconsolidated, sandy siltstone outcrop.

Well preserved mollusk fossils are also found in the same outcrop. Microfossil analysis of the siltstone suggest an early Pleistocene age (about 2.58-0.77 million years old). The discovery of this fossil proved important as it complements the Plio-Pleistocene gap of the nautilus in the fossil record.

Castro, A. L., Fernando, A. G. S., Peleo-Alampay, A. M., Javellana, G. R. S., Marquez, D. J. D., & Nogot, J. R. C. P. (2020). Rare occurrence of Nautilus sp. fossils from Batangas, Philippines. *Philippine Journal of Science, 149*(3), 495-501.

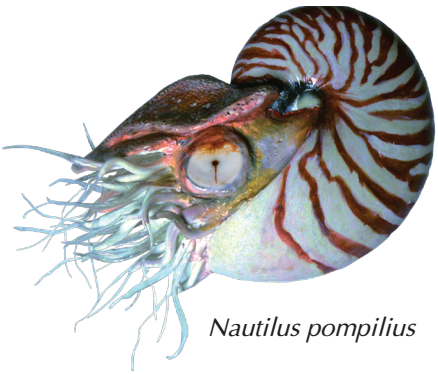
Wani, R., De Ocampo, R., Aguilar, Y., Zepeda, M., Kurihara, Y., Hagino, K., Hayashi, H., & Kase, T. (2008). First discovery of fossil Nautilus pompilius Linnaeus, 1758 (Nautilidae, Cephalopoda) from Pangasinan northwestern Philippines. *Paleontological Research, 12*(1), 89–95.

Lateral View

Apertural View

5 cm

SIZE RELATIVE TO 5-FT WOMAN



Nautilus pompilius

Crinoids

Echinoderm

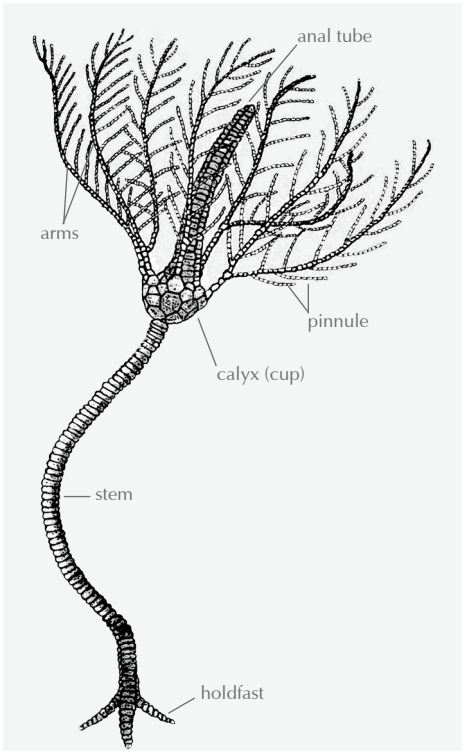
Crinoids (cry'-noids), also known as sea lilies, live in the world's oceans since the Ordovician Period, over 230 million years before the dinosaurs. They make look like flowers, but they are actually some of Earth's earliest animals. Starfishes, sea urchins, and sea cucumbers are their closest relatives.

Crinoids are filter feeders. Their feathery tentacles sieve the passing seawater for microscopic organism as food. A stem made of many stacked discs supports the head, while a root system at the base, called a holdfast, is used to anchor themselves to the seabed.

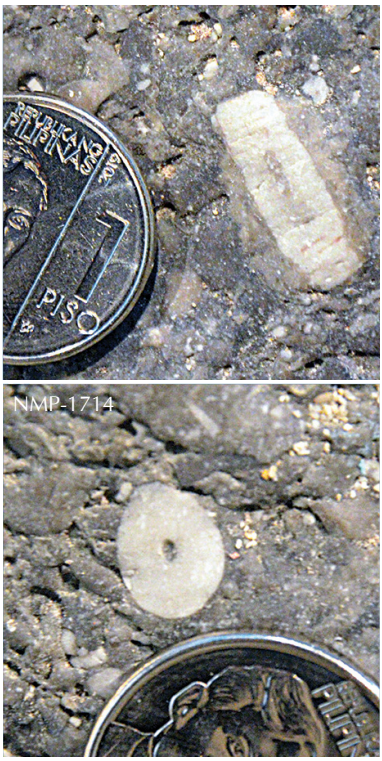
Complete fossil crinoids are rare. When the soft tissue that holds its body together decay, the skeleton typically scatters into several pieces. The most common crinoid fossils are the stem pieces. In May 31, 1965, the Geology and Paleontology Division of the National Museum of the Philippines discovered two crinoid stems (NMP-110a) preserved in shale in Siange, Bongabong in Oriental Mindoro. The specimens are 1.2 cm and 1.4 cm long, and considered Jurassic in age (over 150 million years old). A few crinoid stems (NMP-1714) were also found in Manual, Mansalay, another town in Oriental Mindoro, last December 11, 2016. The specimens are embedded in a boulder, together with other fossils of rugose corals and foraminifera of Permian age (about 275 million years old). Crinoid fossils like these indicate that rocks containing their remains were formed in a marine environment.

Crinoids are considered as living fossils since these ancient animals can still be found in the oceans today. Although most crinoids died out during the Permian Mass Extinction, one group of crinoids survived and gave rise to over 600 species still living today. In the Philippine waters, living specimens were obtained from the northern seaboard of Aurora Province, the Verde Island Passage, and the Sulu Sea at depths of 160 to 1,330 meters.

Crinoid stems in shale (arrows) from Bongabong, Oriental Mindoro.
10 centavos coin =17 mm diameter



Crinoid anatomy



Crinoid stems in boulder from Mansalay, Oriental Mindoro. 1 Peso coin = 23 mm diameter.

Sea Urchins

Echinoderm

In England, hundreds of fossil sea urchins were found encircling the skeletal remains of a young woman and a child in a gravesite dating back to the Bronze Age. In other prehistoric burial sites, a single fossil urchin was observed in pouch bags together with the skeletal remains. Such practice meant that fossil sea urchins attained a high degree of spiritual importance in the past. The people of Denmark and England call them thunderstones and thought they were given by Thor, the Norse god of thunder, and are meant to protect them from evil. But why fossil sea urchins in particular? Many believe it is because of the distinctive five-pointed star pattern on the fossils. Can you see this star pattern in the featured fossils?

Sea urchins are marine invertebrates that first appeared during to the Late Ordovician Period (450 million years ago). They belong to the Echinoderm group, together with the starfishes and the sand dollars. Like other echinoderms, they possess a five-sided radial symmetry, which is reflected in the star pattern, easily seen in dried or fossilized sea urchin. Sea urchins are preserved in the fossil record through their calcareous skeleton called tests and through their spines. When the urchin dies, the spines fall off the tests and may fossilize separately. The tests come in many different forms and shape. The globular-shaped ones are called regular urchins and are usually found lying in the seabed. The flattened and sometimes heart-shaped ones are called irregular sea urchins. They burrow into the sediment and prefer the calm and low-energy part of the oceans. These characteristics help geologists interpret the ancient environment of the rocks where the fossil sea urchins were found.

Fossil sea urchins from the National Geological and Paleontological Collections consists of club-shaped spines and tests of both regular and irregular forms. These specimens were collected by the Geology and Paleontology Division from Isabela, Pangasinan, Zambales, Batangas, Sorsogon, Leyte, Camarines Sur, and Cebu. The first fossil urchin collected was a test of a regular sea urchin (NMP-201; no. 5) from Balamban, Cebu in 1973. It was discovered by geologist Inocentes Paniza of the National Museum. Fossil sea urchins collected from Batangas were found in an outcrop of the Calatagan Formation. The age of this formation is late Miocene-early Pliocene (11.63 – 5.33 million years old).

1-2 sea urchin spines
3-6 regular urchin tests
7-9 irregular urchin tests
7 *Pericosmus* sp.
8 *Taimanawa* sp.

Corals

Cnidarian

Ever wonder why you sometimes find corals several kilometers away from the ocean, or even in mountaintops? Those corals are most likely fossils, and they are an excellent reminder that the land was once under the sea.

Corals are often confused with rocks due to their tough exoskeletons. Sometimes, they are mistaken for underwater plants, particularly the gently swaying soft corals. But in fact they are actually made up of thousands of tiny animals called polyps. These polyps are invertebrates (animals without backbones) called cnidarians like their close cousins – the sea anemones and jellyfish. The polyp uses calcium carbonate ions from seawater to build the hard exoskeleton that will protect their soft and delicate body. This exoskeleton is usually preserved as fossils, and eventually forms part of the rock called limestone.

It is very common to find fossil corals in the Philippines, especially in limestone area, because the archipelago was born from the sea. The oldest fossil coral discovered in the country is *Gshelia* sp., a rugose coral found in the province of Mindoro and is about 300 million years old (Pennsylvanian). That's even older than the dinosaurs! The coral was contained in a clast of highly indurated sandy, dark gray mudstone near the base of the Punso Conglomerate. You can also find fossil corals that date back to the dinosaur age in the Caramoan Peninsula, Cebu, Palawan, and Mindoro.

Corals, however, have been around on Earth much longer than that. They first appeared about 541 million years ago in the Cambrian Period. More interestingly, they are known to be very sensitive to changes in climate. The elemental composition of their exoskeletons can vary with temperature, salinity, cloud cover, river discharge, upwelling, and ocean circulation. This make corals an excellent natural archive of the Earth's sea level, salinity and temperature at different times in history, allowing scientists to study the Earth's past climate trends. This sensitivity, however, also makes them vulnerable to dramatic changes in their environment, which led them to experience a number of extinction events throughout their lengthy existence. With our present climate undergoing a rapid global warming event, driven by increased greenhouse gases mainly from human activities, it is believed that corals are likely to disappear by the year 2100.

Easton, W. H., & Melendres, M. (1964). A Paleozoic coral from Mindoro. *Journal of Paleontology*, *38*, 412-414.

1

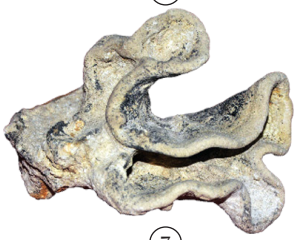
2

3

4

5

6



7

8

9

10

1 *Porites* sp.
2 *Acropora* sp.
3 *Galaxea fascicularis* (Octopus coral)
4 *Pavona* sp.
5 *Favia* sp.
6 brain coral
7 fossil coral
8 *Flabellum* sp.
9 *Fungia* sp.
10 coral colony

Megalochelys sondaari

Luzon Giant Tortoise

Reptiles are four-legged vertebrates (having backbones) that are covered in scales, bony plates, or combination of both. They breathe air only through their lungs, and most of them lay eggs on land. They are cold-blooded, which means their metabolism depends on the temperature of their environment. Reptiles include the dinosaurs that lived hundreds of million years ago. In the ancient past, the Philippines was also inhabited by a giant reptile - the Luzon Giant Tortoise.

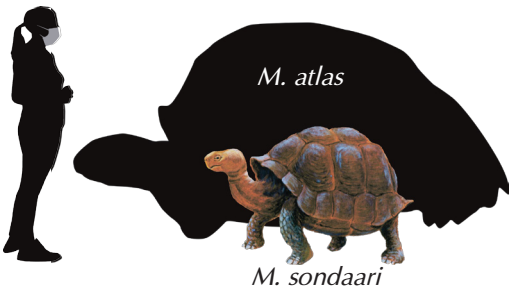
Known by its scientific name *Megalochelys sondaari*, the Luzon Giant Tortoise inhabited the island of Luzon from the Early Pleistocene (2.58 million years ago) until about 1.7 million years ago. Its carapace (top of the shell) was about 70 to 90 cm in length. The first remains found of this giant reptile were pieces of the carapace discovered at Espinosa Ranch, Liwan, Kalinga-Apayao (now Rizal, Kalinga) in 1971, and in San Juan, Tuao, Cagayan in 1976. Back then, its identity was still unknown, until 1989 when several fossilized bones were unearthed in Tres Hermanas, Antipolo City, Rizal by German geologist Dr. Walter Schoell and Filipina geologist Dr. Alyssa Peleo-Alampay from the National Institute of Geological Sciences, University of the Philippines, Diliman. The fossils include humeri (long bone of the upper arm), femurs (thigh bone), coracoids, phalanges (singular: phalanx, digital bones of the feet), and shell fragments. These fossils were first described in the genus *Manouria* by Karl and Staesche (2007), but was later transferred to the genus *Megalochelys* (Rhodin et al., 2015). *Megalochelys* tortoises lived across Asia, and were among the largest Testudines (turtles and tortoises). The carapace of the largest species *Megalochelys atlas* from India, Myanmar and Thailand could reach over two meters in length.

It is believed that the local extinction of giant *Megalochelys* tortoises from various islands in the Indo-Autralian archipelago is linked to the migratory arrival of the early hominin, *Homo erectus*, and their subsequent overexploitation of the animal. Today, many species of turtles and tortoises could also disappear forever because habitat loss, the illegal pet trade, and extensive consumption for food and traditional medicine.

Karl, H. V., & Staesche, U. (2007). Fossile Riesen-Landschildkröten von den Philippinen und ihre paläogeographische Bedeutung (Fossil Giant Land Tortoises from the Philippines and their paleogeographic importance). *Geologischesahrbuch, 98*, 171–197.

Rhodin, A. G. J., Thomson, S., Georgalis, G. L., Karl, H. V., Danilov, I. G., Takahashi, A., de la Fuente, M. S., Bourque, J. R., Massimo D., Bour, R., Iverson, J. B., Shaffer, H. B., & van Dijk, P. P. (2015). Turtles and tortoises of the world during the rise and global spread of humanity: First checklist and review of extinct Pleistocene and Holocene chelonians. *Chelonian Research Monographs*, *5*(8), 000e.1–66.

SIZE RELATIVE TO 5-FT WOMAN



1 shafts of femur
2 fragments of carapace
3 phalanx of the front limb
4 coracoid
5 right humerus
6 femur

Otodus megalodon

Giant Shark

Megalodon (means "giant tooth") is an extinct species of sharks that appeared about 20 million years ago. They are considered not only the biggest shark but also the largest fish to have ever existed. They were estimated to grow to up to 15-18 meters in length, which is bigger than our standard buses!

Similar to sharks today, megalodon had skeletons mostly made of cartilage – the flexible material in our noses and ears. Cartilage rarely survives fossilization. That is why almost all their discovered fossils in all continents except Antarctica are teeth. And most of what we know about megalodons like their diet and size are only based on the size and appearance of the fossil tooth.

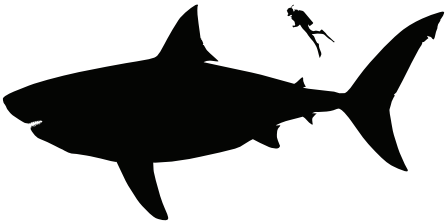
In the Philippines, several fossilized megalodon teeth have been discovered and some are on display in the "Life Through Time" Gallery of the National Museum of Natural History. In 2001, a number of these teeth were unearthed in Pangasinan during an archeological excavation, the largest of which measures 9 x 10 cm. Two other specimens were discovered from late Pliocene (3.6 to 2.6 million years ago) deposits of the Lower Ilagan Formation in Gattaran, Cagayan and measure 11 x 12 cm and 8 x 8 cm. And more recently, the second megalodon tooth in Maribojoc, Bohol was unearthed and it is 7.6 x 6.5 cm. The first one, measuring 10.5 x 6.5 cm, was donated to the National Museum of the Philippines by Venjo Busalla in 2018.

The exact reason for the megalodon's disappearance about 2.6 million years ago is still unknown. Two possible reasons may have caused their eventual demise. One is attributed to cooling global climate that prompted the migration of whales (their primary prey) towards colder Antarctic waters where they could not go. Another is the evolution and diversification of new breeds of competitors like the smaller and nimbler great white shark.

Cooper, J. A., Pimiento, C., Ferrón, H. G., & Benton, M. J. (2020). Body dimensions of the extinct giant shark Otodus megalodon: A 2D reconstruction. *Scientific Reports, 10*, 14596.

5 cm

SIZE RELATIVE TO HUMAN



Istiompax indica

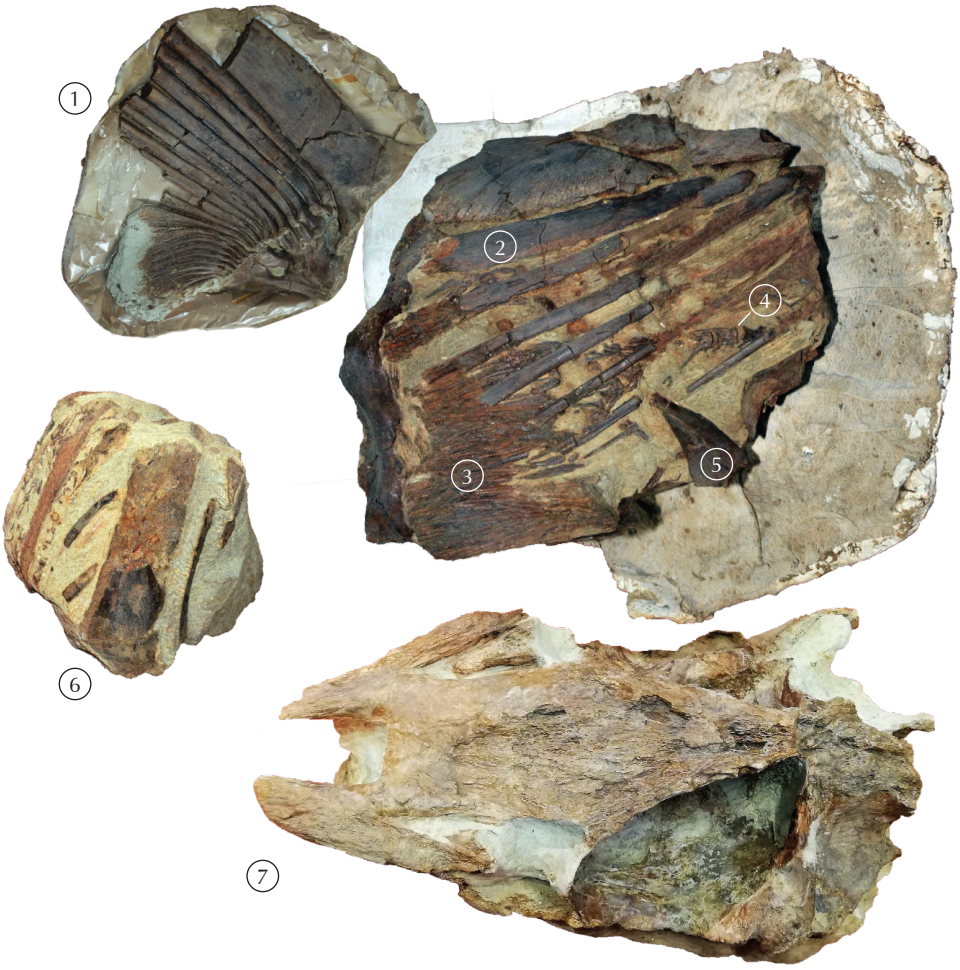
Black marlin

Black marlins (also called short-nosed swordfish or silver marlin) are a commercial or recreational type of fish that inhabit the tropical and subtropical waters of the Pacific and Indian Oceans. They are large, fast-swimming, growing to about 5m and weigh as much as 700kg. Classified as billfish or istiophorids, they belong to a group of predatory fish with spear-like bills used for catching and slashing prey. Considered apex predators, black marlins (*Istiompax indica* formerly *Makaira indica*) usually feed on other large fish such as tuna, mackerel, and swordfish. Black marlins have non-retractable fins, in contrast to other marlin species. In Philippines' seas, black marlins are uncommon. Most of what is in the market are imported from abroad.

The fossil of black marlin (NMP-253, featured here) found in Tambac Island, Pangasinan is a record-setting fossil at the time it was published in 1983 by Harry Fierstine and Bruce Welton. It was the first report of a bony fish fossil in the Philippines, the first billfish fossil to be described in Asia, and the first living species of billfish to be positively identified in the fossil record. This fossil has a nearly complete articulated head with pectoral and pelvic girdles and fins. Interestingly, a portion of the spine of a "swallowed prey", presumably a small fish, can also be seen embedded near the throat region of the fossil.

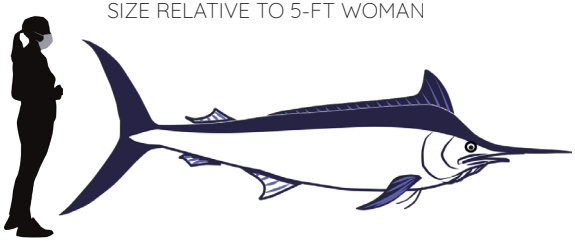
Recovered from a silty sandstone layer, this fossil was also surrounded by large amounts of volcanic ash. The excellently preserved condition of the fossil could be attributed to its rapid burial in an ash fall. Based on studies of fossil foraminifera found with the specimen, this black marlin is believed to be about 2.58 to 1.8 million years old (Early Pleistocene). The estimated length of the animal, from the tip of the lower jaw to the tip of the tail, is at least 350 centimeters, and its weight is over 455 kilograms. Its male, however, seldom grow more than 270 centimeters long, which suggests that this black marlin is female.

Fierstein, H. L., & Welton, B. (1983). A black marlin, Makaira indica, from the Early Pleistocene of the Philippines and the zoogeography of Istiophorid billfishes. *Bulletin of Marine Science*, *33*(3), 718-728.



40 cm

SIZE RELATIVE TO 5-FT WOMAN



1-5 right side of throat region
1 pectoral fin
2 branchiostegal rays
3 breast scales
4 swallowed prey
5 anterior process of cleithrum
6 bone fragments
7 neurocranium (skull part)

Freshwater Fish

Fish vertebrae (NMP-0244) were recovered in Taguig in 1974 by Filipino archeologist and former NMP Assistant Director Alfredo E. Evangelista. They range from 2.3 to 3.15 cm in diameter and up to a centimeter in thickness. These circular bones once formed the spine (backbone) of the fish. Although the identity of the fish are not yet known, the size of the vertebra in this case can give us an idea of their size. Meanwhile, fossilized remains of small fish have been collected in Antipolo, Rizal in 2014 by the NMP Geology and Paleontology Division. These rust-colored skeletons were discovered after splitting the tuff beds exposed in Cogeo. Features in the rocks (well-sorted, fine-grained sediments having pronounced horizontal bedding, etc.) indicates that the fish settled to the bottom of an ancient lake. A whole-body specimen, which also the largest among the batch, suggests a length (head to tail) of just over 8.5 cm.

The rocks where the vertebrae and small fish were recovered belong to the Guadalupe Formation. This formation, which also underlies Metro Manila, was named for the tuff sequence exposed along Pasig River in Guadalupe, Makati City. The fish are believed to have lived between 2.58 million to 12, 000 years ago (Pleistocene) because of the presence of other vertebrate fossils like stegodons, elephants and deers found in the formation.

How did these fish became fossils? Usually, the bodies of dead animals and other living things are completely destroyed by decay or eaten by other scavenging animals. The fossilized small fish in particular probably survived those two scenarios by being buried by heavy ash fall brought by volcanic eruptions during those times. Overtime, the soft body parts decomposed leaving only the fish's skeletons. Minerals from the water seeping through the sediments gradually replaced the bony materials. The mineralized skeleton hardened and turned into stone. Eventually, sediments deposited on top of the previously laid out volcanic or tuffaceous materials. As new layers of sediments build up, the skeleton may be squashed flat. The weight and pressure of the layers above caused the volcanic ash surrounding the fossil to turn into rock called tuff.

More work are still needed to identify these freshwater fish, and paleontologists will have to have luck on their side to discover more exceptionally preserved specimens to understand the dynamics of fish fauna through time.

1 fish vertebrae
2 fossil fish in tuff

4 cm

Elephants

As the world's largest living land mammal, elephants are a sight to behold. For most Filipinos, Mali the Manila Zoo's elephant is their first and only encounter with the animal. But do you know that these gentle giants once roamed the Philippines about 750 thousand years ago? Or that there was at least one species with a shoulder height of only 1.2 meters?

Remains of ancient elephants have been discovered in Cagayan Valley, Pangasinan, Rizal, and Iloilo. Most of them are molars, tusk and bone fragments, belonging to large elephant species *Palaeoxodon* sp., *Elephas namadicus*, *Elephas* cf. *namadicus*, and *Elephas* sp. Based from the molar size, the size of these elephants is similar to that of the living Asian elephant (*Elephas maximus*), found today in India, Nepal, and Southeast Asia. Most of the fossils, however, are typically fragmented and do not allow further identification.

It seems, however, that not all Philippine elephants were giants. In 1911, a small lower molar, estimated at 9.5 cm in length, was reported in Cabarruyan Island (also known as Anda Island) in Pangasinan. This is the first fossil elephant found in Luzon. It belonged to a new extinct species, *Elephas beyeri*, named after Henry Otley Beyer, the Father of Philippine Anthropology. Based from the molar, *E. beyeri* is believed to be a species of dwarf elephant, having a shoulder height of only 1.2 meters. Compare this to the shoulder height of carabaos (1.5 to 1.8 meters). The cause of its dwarfism is suggested to be a response to the limited natural resources in a small environment, like the Luzon Island.

The Philippine elephants have long been extinct, and now we are in the brink of seeing their last living relative, the Asian elephants (*Elephas maximus*) for the last time. Unlike the African elephants (*Loxodonta africana* and *Loxodonta cyclotis*), which came out of endangerment, the Asian elephants continue to decline in population. Poaching, trophy hunting, and habitat destruction continue to threaten this species. You can help preserve them by not buying ivory products, and supporting the organizations that are actively committed to elephant preservation.

De Vos, J. & Bautista, A. P. (2002). An update on the vertebrate fossils from the Philippines. *National Museum Papers*, *11*(1), 62-105.

Lopez, S. L. (1971). Notes on the occurrence of fossil elephants and stegodonts in Solana, Cagayan, Northern Luzon, Philippines. *Journal of the Geological Society of the Philippines*, *25*(4), 1-8.

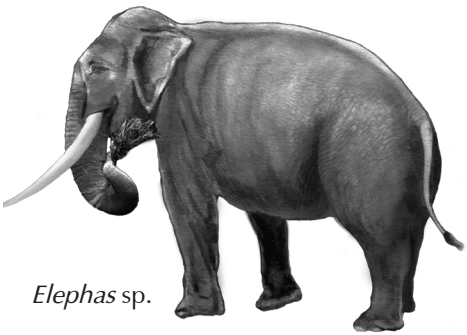
Lopez, S. L. (1972). *Geology and Paleontology of Liwan Plain: Contributions to the Pleistocene Geology of Cagayan Valley*. Seminar on SE Asian Prehistory and Archaeology. Manila, Philippines.

Mathisen, M.E. (1981). *Plio-Pleistocene Geology of the Central Cagayan Valley Northern Luzon Philippines* (Doctorate Dissertation). Iowa State University, USA.

1

2

1 bone fragments
2 molar
3 tusk fragment



Elephas sp.

3

10 cm

Stegodons

Stegodons (meaning "roofed tooth") belong to the now extinct family Stegodontidae of order Proboscidae, where the elephant family also belongs. They were widespread and diverse all throughout Africa and Asia from 11.6 million years ago to late Pleistocene with unconfirmed accounts of survival until about 4,000 years ago. Although they look very close to the two groups of living elephants today, they are actually separated by at least 5 million years of evolution.

The most distinct difference between stegodons and the elephants can be seen in their molars. Compared to elephants that have a series of high-crowned enamel plates, stegodon molars consist of a series of low, roof-shaped ridges that are well-suited for chewing leaves and branches of trees and shrubs. Stegodons also have longer tusks that could grow almost as long as its whole body. These tusks even grow so close together that there wasn't enough space for its trunk to lie in between that they had to lean their trunk sideways.

In the Philippines, scientists identified four (4) species of stegodons, namely: *Stegodon* cf. *trigonocephalus*, *Stegodon* cf. *sinensis*, *Stegodon luzonensis* and *Stegodon mindanensis*, the last two being endemic. *Stegodon mindanensis* is the first large fossil mammal to be scientifically reported in the Philippines. It was first collected by Karl Semper in 1860 in the Agusan River Valley, Mindanao. This species is a dwarf stegodon, weighing only about 400 kg.

Similar to modern elephants, stegodons were likely to be capable swimmers as shown by the widespread encounters of their fossils in the islands of Luzon (in Cagayan, Kalinga, Rizal, and Pangasinan), Panay and Mindanao, and the neighboring islands of Japan, Taiwan, and Indonesia. The exact reason of their demise, however, is still unknown. Changing climates, unfavorable geographical conditions, competition with other species and probably human interaction may have been a factor for their eventual extinction.

De Vos, J. & Bautista, A. P. (2002). An update on the vertebrate fossils from the Philippines. *National Museum Papers*, *11*(1), 62-105.

Lopez, S. L. (1971). Notes on the occurrence of fossil elephants and stegodonts in Solana, Cagayan, Northern Luzon, Philippines. *Journal of the Geological Society of the Philippines*, *25*(4), 1-8.

Lopez, S. L. (1972). *Geology and Paleontology of Liwan Plain: Contributions to the Pleistocene Geology of Cagayan Valley*. Seminar on SE Asian Prehistory and Archaeology. Manila, Philippines.

Mathisen, M.E. (1981). Plio-Pleistocene Geology of the Central Cagayan Valley Northern Luzon Philippines (Doctorate Dissertation). Iowa State University, USA.

1 molar (tooth)
2-3 jaw bone with attached molar
4 humerus (upper bone of forelimb)
5 manus (front foot)

Stegodon sp.

20 cm

Stegodon tusk from Solana, Cagayan

SIZE RELATIVE
TO 5-FT WOMAN

Nesorhinus philippinensis

Rhinocerus

Rhinoceros or "rhinos" are large mammals, known for the giant horn (or horns) that grow from their snouts. These "horns" are not actually true horns because they are composed of keratin, a fibrous protein found in our hair and fingernails. Today, there are only five living species of rhinoceros. The black rhino and white rhino in Africa, and the greater one-horned rhino, Javan rhino, and Sumatran rhino in Asia. But did you know that there was once a small, endemic species living in the Philippines?

This species is called *Nesorhinus philippinensis* (formerly *Rhinocerus philippinensis*). The first fossils of this extinct herbivore were teeth and bones discovered in 1936 in Laya, Cagayan. They were identified as a new species based on features found in the premolars. On May 13, 1965, a portion of right upper jaw with two well-preserved molars and one broken one (featured here) was unearthed in Fort Bonifacio in Metro Manila. It was preserved under thick, compacted volcanic ash deposit of the Guadalupe Formation. Since then, more than a hundred fossils were recovered particularly in Cagayan Valley. One of them is a tibia (featured here) – one of the animal's lower leg bone. This tibia is small, comparable with the Black and Sumatran rhinoceros. Measurements of the molars and postcranial materials confirmed that the rhinoceros was small in size.

In 2013, a team of international and local researchers led by Dr. Thomas Ingicco from the Museum National d'Histoire Naturelle unearthed an almost complete skeleton in an archeological site in Rizal, Kalinga Province. The volcanic materials that covered these fossils gave a maximum age of 1 million years while the tooth and sediment was dated around 700,000 years +/- 70,000. Interestingly, these bones have bludgeoned and cutting marks, which suggests that early humans were in the Philippines 700,000 years ago.

Today, the estimated number of living rhinoceros are down to approximately 30,000. Three of the five species (black, Javan, and Sumatran) are critically endangered. In addition to habitat destruction, poaching and illegal trade of rhino horns, which are valued for making ornamental dagger handles and in traditional medicines have led to their dramatic decline.

Bautista, A. P. (1995). Fossil remains of rhinoceros in the Philippines. *National Museum Papers*, *5*(1), 1-9.

Antoine, P. O., Reyes, M. C., Amano, N., Bautista, A. P., Chang, C. H.,Claude, J., de Vos, J., & Ingicco, T., (2021). A new rhinoceros clade from the Pleistocene of Asia sheds light on mammal dispersals to the Philippines. *Zoological Journal of the Linnean Society*, zlab009.

Right upper jaw with molars (NMP-0105a)

5 cm

Distal part of the tibia (NMP-0285)

10 cm

Nesorhinus philippinensis

Celebochoerus cagayanensis

Pig

Some 800,000 years ago (Middle Pleistocene) in the island of Luzon, there lived a giant species of suid (pigs). Fossil teeth of this animal (featured here) were discovered by the National Museum of the Philippines' Geology and Paleontology Division in Liwan (now Rizal), Kalinga in 1971 and Solana, Cagayan in 1978. In 2016, a team led by Dr. Thomas Ingicco, a professor at the Muséum National d'Histoire Naturelle in Paris, France, and a NMP Research Associate, identified the fossils to be from a new species of pigs, which they named *Celebochoerus cagayanensis*, after Cagayan Valley. Prior to this, *Celebochoerus*, a unique suid having enormous upper tusks, was known to have only existed during the Pliocene-Pleistocene (about 5.33 million to 12,000 years ago) in Sulawesi, Indonesia.

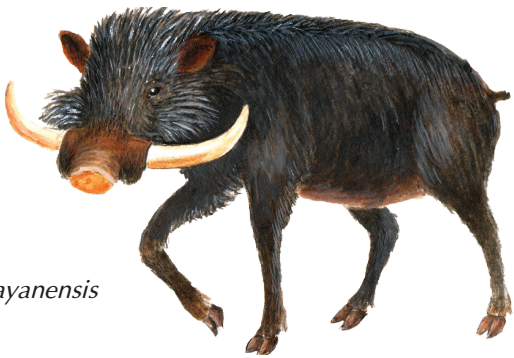
The Philippine species differs from the Sulawesi species *Celebochoerus heekereni* in having distal enamel bands on its upper canines. It is believed that the pig's ancestors arrived in the Philippines from Taiwan, and eventually migrated to the Indonesian island of Sulawesi. This migration route would have occurred independently from the better-known Pleistocene (2.58 million to 12,000 years ago) migration route from India into Java.

C. cagayanensis are already extinct, and the geographical expansion of anoa (dwarf buffalo), babirusa (deer-pigs) and warty pig, which have produced competition, may have been the cause. Today, however, even these animal faces extinction. Once such example is *C. cagayanensis*' distant cousin – the Visayan warty pig. It can be found in the past throughout the Visayan Islands but are currently extinct on all but the islands of Panay and Negros.

Deforestation, hunting for consumption, interbreeding with domestic pigs and killing for various reasons are the major causes of the sharp decline in numbers. It is thought that there are only 200 Visayan warty pigs surviving in their native habitat, which classified them as Critically Endangered (CR) on the International Union for Conservation of Nature Red List.

Fortunately, there are already efforts to save the Visayan warty pig through breeding centers established in Panay and Negros, a small step in increasing their number but a big leap in saving the species from extinction.

Ingicco, T., van den Bergh, G., de Vos, J., Castro, A., Amano, N., & Bautista, A. (2016). A new species of Celebochoerus (Suidae, Mammalia) from the Philippines and the paleobiogeography of the genus Celebochoerus Hooijer, 1948. *Geobios*, *49*(4), 285-291.



Celebochoerus cagayanensis

Rusa sp.

Deer

The fossils featured here are antlers (sungay ng usa in Filipino) from *Rusa*, a genus of true deers that also include the Philippine brown deer (*Rusa marianna*) and Visayan spotted deer (*Rusa alfredi*), two of the three endemic deers in the Philippines.

Although the term antler and horn have been used interchangeably, there are significant differences between the two. Horns are made up of a bone core covered by keratin, the same material as our fingernails. They are permanent and continue to grow throughout the animal's life. Meanwhile, antlers are composed of solid bone, but are shed and regrown annually in a branching manner, often taking on complex pattern.

In 1970s, several antlers were discovered in Solana (NMP-0211) and Tuao (NMP-0369) in the province of Cagayan, while a few were found in Anda, Pangasinan, and Quezon, Palawan (NMP-0154). These fossils are believed to be of Pleistocene age. In particular, the specimen NMP-211 from Solana consists of the burr, a broken brow-time, and a part of the beam with a length of only 20 cm. This is believed to belong to a small species of male *Rusa* since antlers are only grown by male deers. And like those in modern deers, these were likely used by the prehistoric deers in clashes over potential mates.

Today, the descendants of these deers are distributed across the Philippines. Their population, however, is severely fragmented and reduced because of habitat loss and hunting. The Visayan spotted deer (*Rusa alfredi*), for example, is one of the rarest deer in the world. It once roamed the islands of Cebu, Bohol, Guimaras, Leyte, Masbate, and Samar, but are now only found in the remaining forest on Panay and Negros islands.


10 cm

Cebu Tamaraw (*Bubalus cebuensis*)

and other Bovids

The tamaraw (*Bubalus mindorensis*) is a critically endangered species of dwarf water buffalo found only on the island of Mindoro, with an estimated population of just 480. But do you know that an even smaller water buffalo once lived in the island of Cebu? It is called *Bubalus cebuensis* or the Cebu tamaraw.

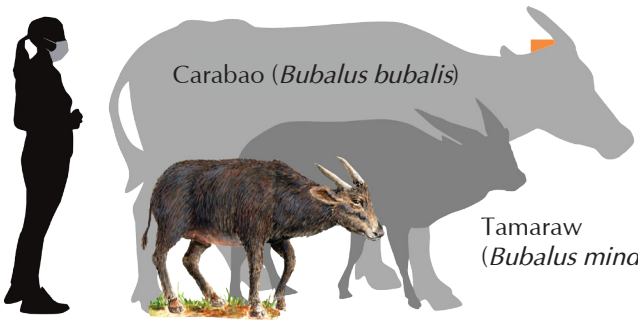
A partial skeleton of the Cebu tamaraw was discovered by accident by mining engineer Michael Armas more than 60 years ago while exploring for phosphate in a tunnel near the municipality of Balamban in island of Cebu. The fossil includes right and left humeri (arm bone, featured here), left metatarsal, 2 vertebrae, 2 unguals, and 2 molars. It was only in 2006, however, that these were found to be from a new species of extinct dwarf buffalo (Croft et al., 2006). *Bubalus cebuensis* was 25% smaller than the Mindoro dwarf buffalo (*Bubalus mindorensis*), standing only 75 centimeters at the shoulder and weighing about 150 to 160 kilograms. Although its exact age is not yet known, the fossil is believed to be of Pleistocene in age, between 10,000 and 100,000 years ago, but it is possible that it is younger.

The Cebu tamaraw is an excellent example of island dwarfism in the family of Bovidae (buffalos, sheeps, goats, cows). Living in an island with limited resources and lack of the usual competitors and predators have produced this dramatic body size changes.

Aside from *Bubalus cebuensis*, fossil teeth and bone fragments of unidentified *Bubalus* species (feature here) were also unearthed in the provinces of Cagayan and Pangasinan since 1957. They were identified to be from small buffalos related to Bubalus mindorensis, and may suggests that the animal were more widespread prehistorically in the island of Luzon.

Croft, D. A., Heaney, L.R., Flynn, J.J., & Bautista, A.P. (2006). Fossil remains of a new, diminutive Bubalus (Artiodactyla: Bovidae: Bovini) from Cebu Island, Philippines. *Journal of Mammalogy*, *87*(5), 1037–1051.

1 Right upper and lower arm of Cebu Tamaraw (*Bubalus cebuensis*)
2 Bovid bone fragments (*Bubalus* sp.)
3 Bovid teeth (*Bubalus* sp.)



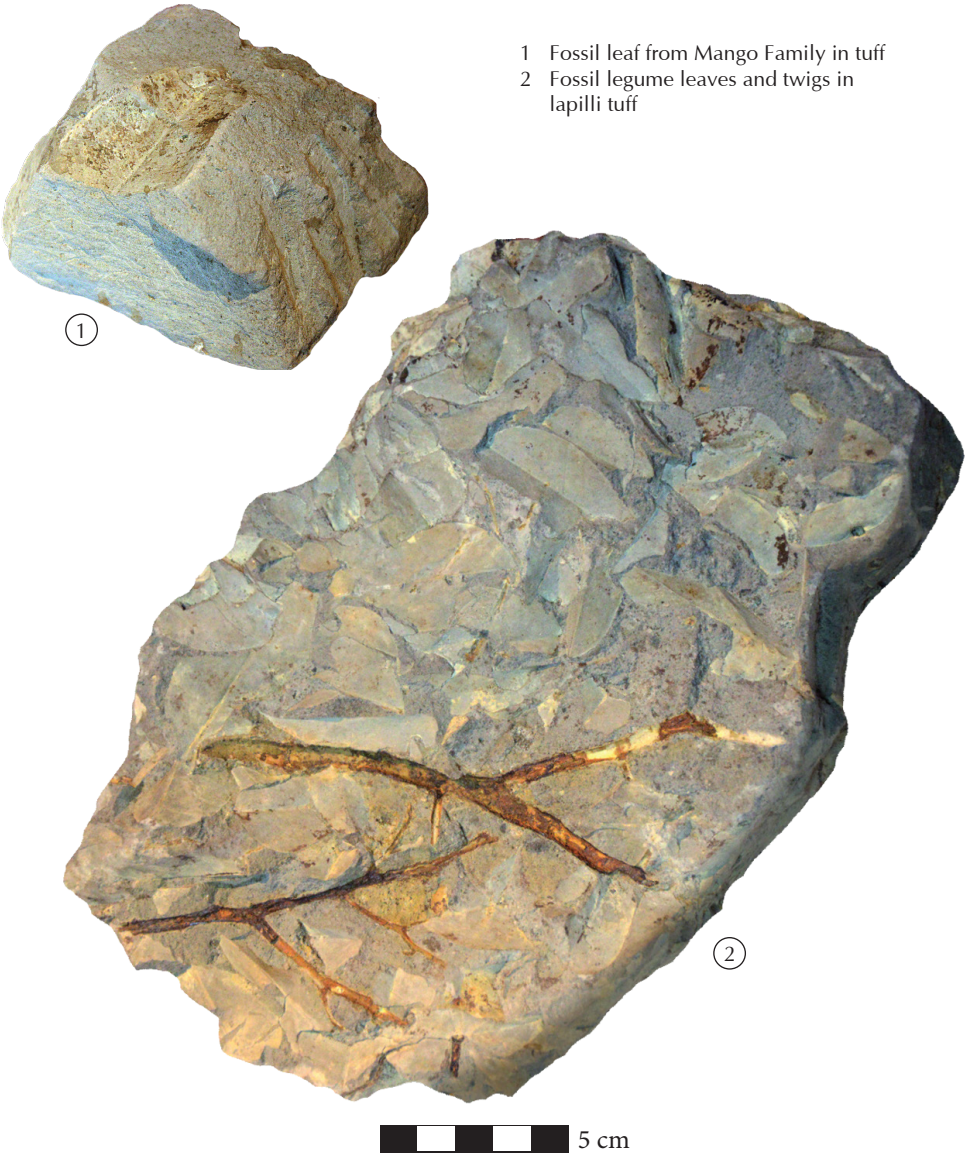
Fossil Plants

Fossils of elephants, stegodons, and rhinoceros certainly are spectacular evidence of the Philippines' bygone wildlife. But alongside them were the shrubs, trees, and grasses that provided them both food and habitat, while making our scientists understand what our environment was like in the past.

The fossils featured here were once flowering plants (angiosperms) that flourished in the Philippines during the Pleistocene Epoch (2,580,000 to 11,700 years ago). It was during the Pleistocene that the Earth experienced the most recent episodes of global cooling (Ice Ages). These dramatic shifts in climate and temperature, as well as the appearance of humans, are believed to have caused the extinction of the giant animals. On the other hand, little change has occurred on what vegetation types have thrived in Philippine soil as most of the fossil plants, like these five featured here, have all survive to this day.

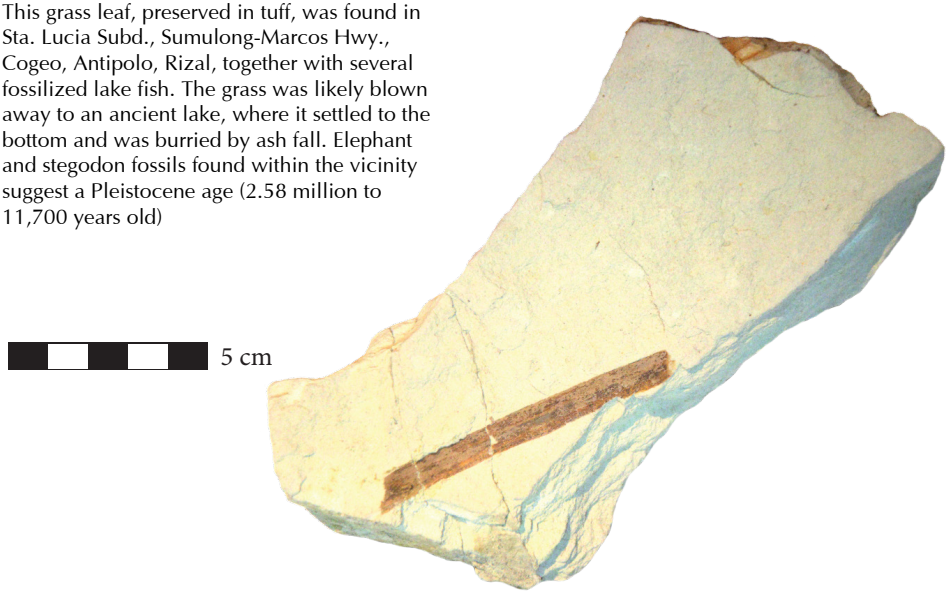
Fossil plants are important in the reconstruction of ancient ecological system and climate. They are also fundamental in studying the evolution and distribution of modern plants. But because they are usually found as separated leaves or twigs, identification are difficult. Fruits, seeds, and flowers can also be fossilized, although less commonly.

So how do plants become fossils? Essentially, they must be out of reach of scavengers and decomposers, like bacteria or fungi that would eat or destroy them. This happens frequently in estuaries and deltas of rivers (wawa in Filipino), flood plains, lagoons and lakes. Plants parts like leaves and twigs fall and sink to the bottom of these bodies of water, and become buried by clay, silt, sand, or even volcanic ash like some of our examples here. As sediments pile up, fluids are squeezed out and the lower layers of sediments become more compressed, eventually turning to solid rock. Any plant parts contained within them are flattened. This process destroy the internal structure, leaving only a delicate carbonaceous film that imitates the original outline of the plant part. Such fossils are called compression fossils. More often, however, plant fossils are found with only their imprint remaining. These fossils are called impression fossils. Can you differentiate which among the five examples are compressions and impressions?



(1) Leaf from Mango Family and (2) an assemblage of legume leaves and twigs (related to Kakawate) preserved in tuff (compacted volcanic ash) after an explosive volcanic eruption that happened between 2,580,000 to 11,700 years ago. The fossils weres discovered in Valenzuela City, Metro Manila, sugesting that the area was close to an active volcano.

This grass leaf, preserved in tuff, was found in Sta. Lucia Subd., Sumulong-Marcos Hwy., Cogeo, Antipolo, Rizal, together with several fossilized lake fish. The grass was likely blown away to an ancient lake, where it settled to the bottom and was burried by ash fall. Elephant and stegodon fossils found within the vicinity suggest a Pleistocene age (2.58 million to 11,700 years old)



Leaf from a flowering tree *Dillenia* sp. that grew in Mansalay, Oriental Mindoro 2.58 million to 11,700 years ago. The leaf is preserved in calcareous sandstone, suggesting that the living tree lived close to an estuarine or shallow shelf marine environment.

2,580,000 to 11,700 years old fossil leaves believed to be from the Annonaceae (Guyabano Family) or Myristicaceae (Nutmeg Family) preserved in tuff (compacted volcanic ash). The fossils was collected from Tatalon, Quezon City and was donated to the National Museum on November 19, 1969.

Petrified Wood

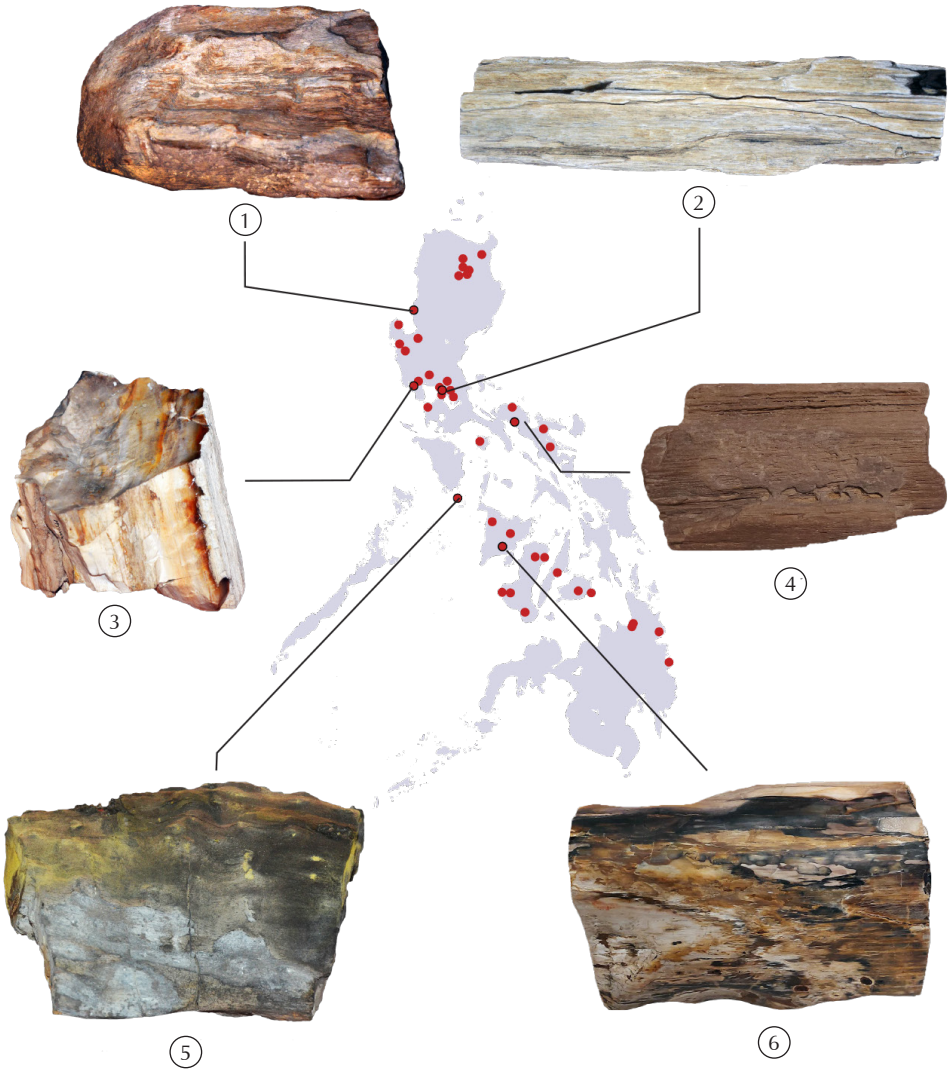
Petrified wood (from the Greek root Petro meaning “rock” or “stone”; combined with wood, the term literally means “wood turned into stone”) is a common kind of fossil plant. It is the result of a tree having turned completely into stone by the process of permineralization.

So how does wood undergo permineralization? Once in a while, a newly-deceased tree (or some other kind of woody plant) gets rapidly buried by mud, silt or volcanic ash. This blanketing material shields the dead tree from oxygen. Because oxygen is the main driving force behind the decaying process, the plant begins to decompose far more slowly than it normally would. Meanwhile, mineral-rich water or mud seeps into the dead tree’s pores and other openings. As the plant’s internal structure gradually breaks down, its organic material (wood fibers) gets replaced by silica and other minerals. Over a period of a few million years, those minerals crystalize. The slower the process, the more precise the replication is. The end result is a rock that adopts the shape and structure of the original tree. In some cases, the replication is so precise that the specific variety of the tree can be identified. When this occurs in highly wooded area or forest, like in some parts of the world, the area is called a petrified forest.

What makes a petrified wood colorful? It’s not the wood but the chemistry of the petrifying groundwater. Chromium, copper and cobalt will give a blue-green color, while manganese and iron oxides will showcase a pink to orange and a yellow to red-brown color, respectively. Silicate dioxides will give the fossil a transparent white to translucent gray color, and carbon, of course, shades it in deep black color.

The Geology and Paleontology Division manages a wide array of petrified wood specimens since 1948 with localities all over the Philippines, specifically from the provinces of Agusan del Norte, Albay, Antique, Bataan, Bohol, Bulacan, Cagayan, Camarines Norte, Camarines Sur, Cavite, Iloilo, Kalinga, La Union, Marinduque, Metro Manila, Negros Occidental, Pangasinan, Rizal and Surigao del Sur. Their ages range from the Middle Miocene to the Pleistocene, about 15 million years to 10,000 years old.

In 2018, Mr. Lawrence John Gotuaco gifted the nation through the National Museum of the Philippines (NMP) with 88 pieces of foreign and 8 pieces of local petrified wood specimens. Mr. Gotuaco, one of our most generous benefactors, also donated ammonites, minerals and replicas of famous dinosaur skulls and a leg, all collectively known as the Gotuaco Collections.



Localities of Petrified Wood Collections

1 Pagatpat (Family Lythraceae)
2 Molave Tree Family
3 Acacia Tree Family
4 *Vitex* sp. (Family Lamiaceae)
5 Bakawan (Family Rhizophoraceae)
6 Petrified log from Gotuaco Collections

Orbitolina

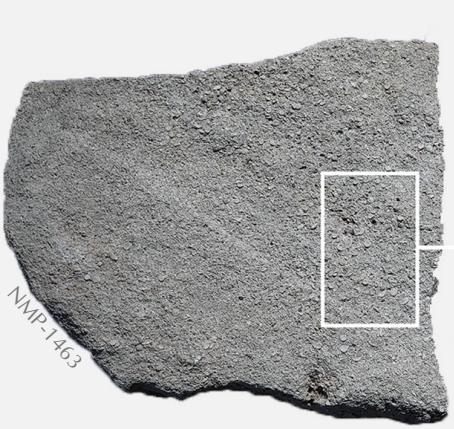
Foraminifera

Do you know that bacteria, protists, fungi, pollens and spores can also be fossilized? Because of their microscopic size, they are collectively called **microfossils**, and they are just as important as, if not more useful than big fossils.

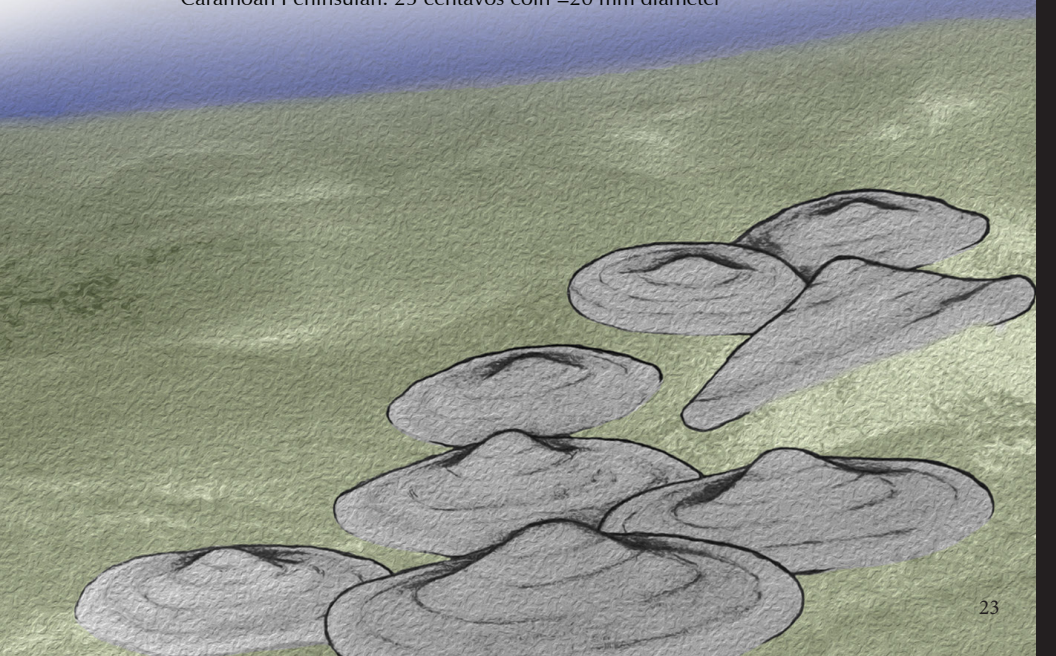
Orbitolina is a foraminifera – a single-celled, amoeba-like organism that makes a tiny shell called a test. This test is flat conical to bowl-shaped, typically < 2cm in diameter, and is made of calcium carbonate, the same material that makes up the exoskeleton of many marine animals. They lived on the seafloor of warm, shallow waters, where they fed on bacteria, diatoms, and other single-celled organisms. Like the T-rex, *Orbitolina* only lived during the Cretaceous Period (145-66 million years ago). But during this time, they were very abundant and widespread in the ancient seas. This made them valuable index fossils – fossils that represent a particular span of geologic time or environment. This means they are important for determining the age of ancient marine rocks.

Part of the National Geological and Paleontological Collections is an *Orbitolina*-bearing limestone (NMP-1463; pictured here). It was collected in Cabacongan, Caramoan Peninsula in 2015 during a collaborative study between the National Museum of the Philippines researchers and Japanese paleontologists. The presence of *Orbitolina texana* and *Orbitolina* cf. *conoidea* in the rock pointed to late Early to early Late Cretaceous age (Aptian to Cenomanian or ~125.0 to 93.9 million years old). Their presence also implied that the area was once a warm, shallow sea. In the Philippines, *Orbitolina* has only been reported in Cebu, Catanduanes, and Caramoan Peninsula.

Microfossils like *Orbitolina* provide us information about the diversity of ancient life. They not only help geologists determine the relative ages of rocks, but also infer past environmental conditions, including the chemistry of the water in which they once lived, making them crucial in understanding climate change. They are also used to find petroleum deposits. This goes to show that big things truly come in small packages!



Microfossils of *Orbitolina* spp. (arrows) in Cretaceous age limestone from Caramoan Peninsulan. 25 centavos coin =20 mm diameter



Coprolites

Trace Fossil

Fossils do not always represent a body part of an organism. Sometimes, they can be human footprints, a snail's track marks, a bird's nest, or traces of the roots of plants (rhizoliths). They can also be fossilized poop called coprolites. These type of fossils are called **trace fossils** or **ichnofossils** (Greek: ikhnos meaning "trace" or "track") and they are the physical record of an organism's biological activities while it was alive. In the case of coprolites, they can contain clues about the animal's diet. Was the animal a meat-eater or a vegetarian?

Among the first collections in the National Geological and Paleontological Collections are these coprolites (NMP-010) from Mansalay, Oriental Mindoro. Coprolites contain clues about an animal's diet. These type of trace fossils were collected in 1948 by GPD's first chief geologist, Mr. Inocentes Paniza, in a rock exposure in Tignoan Creek. These coprolites were found together with 152-163.5 million year old (Late Jurassic) ammonite fossils. Could these ancient feces be from ammonites or some other creature in the Jurassic seas?


NMP-010
NMP-010
NMP-10
5 cm

Ancient Homes and Tracks

Trace Fossils

Trace fossils are indirect evidence of ancient life. They are essential at helping us understand some behavior that bones or shells can't tell us. They tell us how an organism moves, gives an idea of the size of the organism, provide clues to their feeding behavior, or tell what kind of environment an organism lives on. For organisms that do not have hard shells or bones, like jellyfish, slugs, and worms, these may be the only evidence that they existed.

The sandy tubes in the rock featured on the right were once deposit-feeding burrows and open dwellings in the mud that later became filled with sand. Most are horizontal (parallel to bedding) and branching with few vertical burrows (circular in cross-section). Crustaceans like burrowing shrimps and crabs make similar burrows in the sediment today. The NMP-GPD together with geologists from UP-NIGS and NMNS-Japan collected this sample from Ilagan, Isabela. It belongs to the 8.2 - 5.5 million years old Cabagan Formation.

Meanwhile, the winding, ribbon-like feature in the other mudstone is a trace fossil known as *Scolicia*. *Scolicia* is interpreted to record the locomotion or feeding trace of an ancient sea urchin. This fossil provides insight into not only the direction the organism took but also its behavior while plowing through sediments. This specimen was found by Mr. Joel Sarmiento in Dipujen River of Palanan, Isabela and was donated to the National Museum in 2017.

However, it is worth noting that one organism can make thousands of traces in its lifetime, and an entirely different organism may produce identical tracks. As a result, they are more common than body fossils, but more enigmatic for scientists to study. They may also hold outstanding paleontological value. Do you know that the oldest fossils found on Earth are trace fossils? These are the fossilized traces of cyanobacteria or blue-green algae called stromatolites, found in the rocks of western Australia, and dated 3.5 billion years old.

Ancient burrows (arrows) in mudstone

Scolicia isp.(sea urchin trace) in mudstone

Contributors
Elisha Gabriel C. Riza
Paolo B. Omana
Edward David L. Francia
Loudel S. Gaciles
Aryssa Orven E. Martin

Acknowledgment
Priscila A. Ong
Roberto SP. De Ocampo
Dr. Michael D. Purugganan

Front cover art (two stegodons and an elephant)
by Roderick Macutay

National Museum of Natural History

Open Tuesdays to Sundays, 10 AM to 5 PM
Padre Burgos Avenue, Ermita 1000 City of Manila
www.nationalmuseum.gov.ph
inquiry@nationalmuseum.gov.ph
nationalmuseumofthephilippines
@nationalmuseumph
@natmuseumph